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to be taken into account, such as the relation for nutrients between the mother and the foetus and the fact that the majority of the cases complete were associated with the as in maternal diabetes.

Although it is difficult to suppose that one abnormal factor acted on the foetus throughout the whole of the pregnancy, the results produced in the first 3 and in the last 3 months are probably more important than in the middle period. The effects on the foetus differ in these 2 periods; those in the first 3 months being chiefly concerned in maturation and of the last 3 months in foetal immaturity and disease.

Diabetes furnishes an example of a maternal condition which presumably acts throughout the whole of foetal life, and which produces foetal results, since foetal deaths in about 30 per cent of such pregnancies even when the mother receives insulin. Many reasons have been suggested to account for this mortality; the absence of maternal treatment; the presence of maternal complications such as toxæmia; hypotension; anaemia; hydramnios; a large foetus; increased incidence of congenital abnormalities; infantile hypoglycaemia; and there is no general agreement that any of these are causal factors. A recent investigation by Miller, Hurwitz and Kohn¹ produced the following remarkable results: Foetal and neonatal mortality was 5 times greater, and babies weighing over 11 pounds 80 times more frequent among the children of diabetic than among those of non-diabetic mothers. Furthermore, these trends were noticeable before the mothers developed diabetes, and the mortality actually reached this high level 5 years before the onset of the disease. When the diabetes is so mild that the mother did not require insulin when she only had glyco-

suria during the last 3 months of pregnancy and had an otherwise normal carbohydrate metabolism, the increase in mortality was 4-fold. This increase was not due to the size of the child, since the rate was the same for babies between 5½ to 10 pounds as for those over 10 pounds. Autopsies on the new-born children of these mothers showed hyperplasia of the islands of Langerhans; increased erythropoiesis in the liver and cardiac hypertrophy which, in children who survived, disappeared in 6 weeks. These changes also were found in children born before their mothers had signs or symptoms of diabetes.

THE PERIOD OF MALFORMATION.

The 5th to the 9th week of pregnancy is the critical period in the development of the lens, teeth, palate and septa of the heart, and some of the malformations of these organs were attributed by Shakespeare to "the foul fiend Plibbertigibbet" who "gives the web and pin, squints the eye and makes the hare-lip."

1. Malnutrition and Malformations.

There is, however, increasing experimental evidence that congenital deformities of these organs may be due to malnutrition; for instance, Hale² found that the pigs born to sows who were fed on a diet deficient in vitamin A had congenital defects of the eyes, and Warkany³ has recently reported similar findings in rats. Previously, by restricting other articles in the diet of pregnant rats Warkany and his colleagues⁴ had shown that the young rats were born with deformities such as shortening of the mandible; cleft palate; shortening and protrusion of the limbs; syndactyly; fusion of the ribs. Clearly it is difficult to postulate that this state of affairs occurs in 40-75 per cent of the important foetus; indeed, the relation between malformations and nutrition is a complex one. It is not, however, give

pitfalls which beset attempts to draw correct deductions about foetal health. Many doctors maintain that there has been an increase in malformations during the war years, yet it is generally accepted that during this time pregnant women have been more adequately nourished than previously with the result that, again to quote Mr. Churchill, "the death-rate of mothers and of babies has fallen to the lowest figure we have ever known in this country; so has the rate of stillbirth." The fall of the stillbirth-rate from 36 per 1,000 live births in 1940 to 28 in 1943 has indeed been described as one of the major victories of the war. A reduction in neonatal mortality necessarily causes a relative increase in the number of deaths from congenital abnormalities because so many of these are incompatible with sustained life, but in complete disagreement with the views expressed by so many doctors, the returns of the Registrar-General show that, apart from an increase in deaths from hydrocephalus in male infants in the years 1940 and 1941, there was no absolute increase in the deaths from malformations between 1936 and 1943.

2. Infection.

From time to time the possibility that an infection may cause congenital defects has been discussed, and recently the association of German measles in the mother with defects in the foetus has been stressed. The possible connexion between these two conditions was first pointed out by Gregg,* an Australian ophthalmic surgeon, who, in the first half of the year 1941, noticed an unusual number—in fact a mild epidemic—of congenital cataracts among babies; furthermore, the appearance of these defects did not "exactly correspond to the large number of morphological congenital and developmental lesions that have been described." He found that with few excep-

tions their mothers suffered in the early months of pregnancy from an exanthem simulating a severe form of German measles; adenopathy marked, swelling of the ankle and w. joints occurred and the degree of constitutional disturbance was greater than in any epidemic of this disease in his experience. Between December 1936 and January 1941 collected 78 cases of congenital cataract, of which also had congenital heart disease. Moreover, many of the babies were ill, ill-nourished and difficult to feed. Inspired by these findings, Swan,⁹ of Adelaide, and his colleague sent out a questionnaire to all medical practitioners in South Australia asking them to report on all babies born to mothers who had suffered from an exanthemata during pregnancy. As a result they examined 61 infants, of whom 30 showed congenital defects such as cataract, deaf-mutism, heart disease, microcephaly, mental retardation and quite a few multiple defects. Forty-six of these 61 mothers developed rubella during the first 3 months of pregnancy and 30 of their children showed congenital defects; 1 had rubella and measles and the child bilateral cataract; 1 had either rubella or measles and another rubella and mumps both children being normal; 7 had measles and all the children were normal; 1 had mumps and the baby bilateral corneal opacities. The mother of 3 children with congenital defects denied the existence of any disease during pregnancy and the mother of 1 child who had cataract and heart disease had an illness during pregnancy diagnosed as "influenza." On the basis of this evidence the workers draw the somewhat amazing conclusion that "when a woman contracts rubella within the first two months of pregnancy, it would appear that the chances of her giving birth to a congenitally defective child are in the region of 100 per cent and in the 3rd month about 50 per cent."

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... they reported to ... defects in ... and ... material, ... mothers ... congenital defects which ... whose ... the 6th to ... critical period ... In America 14 ... associated with ... been reported ... Many pediatricians ... cited examples, ... has been reported ... means of a questionnaire, found that 1 ... mothers of 24 out of ... in 1940 to 1941 had ... 12 months of pregnancy and 6 others ... baby suffered from it. Some of the children also had defects of the eye, and 3 had defects of both the eye and the heart. Of the remaining 55 cases, the deafness was hereditary in 7 and in 13 was caused by meningitis.

These rather arranging observations suggest three questions.

First: Is the relation between maternal rubella and congenital defect statistically significant? The Australian statistics have been criticized because in some of them only children with positive defects were reported and there was no information as to how many women who had rubella during pregnancy gave birth to normal babies. According to the *method* these studies do not meet statistical requirements and "all babies born of the defined mothers should be observed together, preferably with some comparable group of babies, born of mothers whose pregnancies were not accompanied by any of the diseases in question." It seems to me that the most important point which suggests that the social is a causal and not a chance one

are the facts that (a) the German measles occurred during the first 3 months of pregnancy—that is during the critical months in the development of the organs affected—and (b) that although 8 mothers had other infectious diseases during pregnancy, only 1 instance of congenital deformity occurred among their babies.

Secondly: Since rubella is usually such a mild disease that it may easily be overlooked or wrongly diagnosed, was the maternal illness in fact due to rubella? Gregg thought that the 1940 epidemic was the most severe he had ever seen and wondered if it could be any other exanthem, but came to the conclusion that it was German measles, and there was said to be no other disease epidemic at the time with which the South Australian cases could be confused. The severity of the disease was attributed to an increase in the virulence of the virus due to wartime conditions, particularly to overcrowding in camps. In my opinion, it should be accepted that the disease was rubella, a decision which naturally raises a 3rd question: Why should a disease normally so trivial in the adult and child produce such devastating changes in the foetus? The answer suggested is that in mammals the embryonic cells are more susceptible to virus infections than adult tissues; more severe changes, therefore, should be seen in the foetus and these should be especially marked at the period of greatest embryonic activity, i.e. the early weeks of pregnancy.

The causal relations between rubella in the mother and congenital defects has not been proved and further investigations should be carried out, but the evidence produced is sufficiently convincing to make it unwise for expectant mothers—especially those in the early months of pregnancy—to be exposed to the risk of infection with measles and perhaps with milk production. themata also, although it is not, however, give

justify the termination of pregnancy. On this subject Vertue¹⁶ has made the interesting comment that "Science has done nothing about Flibbertigibbet unless you count the suggestion that one of his other names is German measles."

PERIOD OF FOETAL IMMATUREITY AND DISEASE.

This can be discussed under 3 heads, (1) nutrition and nutritional disorders, (2) immunity, (3) disease.

1. *Nutrition and Nutritional Disorders.*

The normal full-time baby starts life with a satisfactory equipment of vitamins, hormones, metals, etc., but after birth there follows a negative phase in which the store of vitamins diminishes and haemolysis and hypoprothrombinaemia etc., occur. This phase is short where vitamin A and vitamin K are concerned; longer for vitamin D, calcium and phosphorus; longer still for vitamin C, iron and thyroxine; and lasts until the baby is able to obtain these factors from its diet or manufacture them for itself. If storage during pregnancy has been defective owing to premature birth or to inadequate nutrition of or to disease in the mother the diet of the baby may not be able to bring the levels up to normal and morbid conditions, such as haemorrhagic disease of the new-born, nutritional anaemia, tetany, rickets, scurvy develop; diseases which are even more likely to occur if the baby's diet is also defective. Although hypoprothrombinaemia is more marked and lasts longer and therefore the liability to haemorrhagic disease is greater the premature than in the full-time child, it is generally accepted that there is little or no store of vitamin K in the body. In the last month of pregnancy is specified by the authorities.

Hypoprothrombinaemia occurs in liver diseases and the hypoprothrombinaemia of prematurity is probably due to the defective liver function which occurs in prematurity; nevertheless, the foetus can be adequately protected against haemorrhagic disease if the mother is given 5 to 10 mg. of menaphthone subcutaneously directly she goes into labour.

If the mother during pregnancy shows evidence of a deficiency disease the foetus at birth is also likely to be affected with that disease. For instance with 1 exception, the only examples of true foetal rickets are the offspring of mothers suffering from osteomalacia (Maxwell¹⁷). The exception is recorded by Richard Ellis¹⁸: a baby when born at term showed multiple fractures, beading of the ribs hypophosphataemia and typical radiological signs of active rickets although its mother was healthy and had normal long bones on radiological examination. Neonatal tetany occurs from time to time and although sometimes it may be due to haemorrhages into the parathyroid, it is usually due to deficiency of blood calcium in the mother. We can accept it as axiomatic that an unusually early onset of rickets, and frequently also of tetany, in the baby is due to deficiency of calcium, phosphorus and vitamin D in the maternal diet during pregnancy.

Maxwell¹⁹ has reported the occurrence of keratomalacia in infants whose mothers' diet was deficient in vitamin A. Women suffering from beri-beri of pregnancy show a shortage of vitamin B₁, and frequently their offspring are stillborn or show evidence of polyneuritis and Huggett²⁰ states that foetal haemorrhage is said to occur if the mother is lacking in vitamin C.

When the diet of a pregnant animal is deficient the embryo has the prior claim to the nutrients, but iron is sometimes an exception to this rule; this iron anaemia in rats can be corrected.

milk and yeast, but their young are born anaemic (Parsons and Hickmans²¹); again, a baby may develop iron deficiency anaemia shortly after birth, although its mother was not anaemic during pregnancy. If a mother has an iron deficiency anaemia during pregnancy, her baby may not be anaemic at birth but this is not invariably the case; on the contrary, the baby may show an iron deficiency anaemia at or shortly after birth or develop a severe type of nutritional anaemia of infancy (Parsons²¹).

It seems, therefore, clear that everything should be done to prevent the premature birth of the infant and that the mother's diet should be more than adequate and contain full supplies of vitamins, calcium, phosphorus and iron. The storage of these essentials by the foetus is said to take place chiefly during the last third of pregnancy, during which time, according to Huggett,²² two-thirds of its calcium phosphate, three-quarters of its protein and four-fifths of its iron are laid down. Although in great part obtained from experimental animals, there is a considerable amount of evidence to support this view. Hugounenq²³ showed that two-thirds of the iron present in the body of the full-time infant was laid down during the last 3 months of pregnancy; an observation which, in not so far as it concerns the deposit of iron in its chief storage depot, the liver, has been confirmed by Ramage, Sheldon and Sheldon²⁴; these investigators also showed that the storage in the liver of copper and calcium followed similar lines and that the amounts of all 3 elements reached their peak at birth (see Table I). Moreover, their results suggested that an adequate supply of calcium is necessary to ensure the storage of iron and copper.

Indirect evidence of the importance of storage in the later third of pregnancy is provided by the facts that premature

TABLE I.

	Duration of pregnancy		Age at which full-time value is again reached
	0-24 weeks	Full time	
Total Iron (mg.)	15.2	73.3	5th year
No. of examples	6	6	
Total Copper (mg.)	1.33	7.26	5th year
No. of examples	7	8	

infants develop an iron deficiency anaemia at an earlier age and suffer more frequently from rickets than full-time babies. Again, Ebbs, Tisdall and Scott²⁵ found that rickets, tetany and anaemia were more frequent in babies under 6 months of age whose mothers were taking a "poor" diet than in those taking a "good" or a "supplemented good" diet. Nevertheless, their results cannot be accepted as evidence in favour of the point under discussion because the "supplemented good" diet was only "supplemented" during the last 3 months of pregnancy and there were no controls who took this diet throughout pregnancy. The same criticism applies to an investigation carried out by my colleague, the late Dr. Gittins, who gave full doses of iron daily to expectant mothers for 1 to 3 months before delivery and found that their infants had a definitely higher haemoglobin at each age period than those born to mothers who were not given the extra iron. At the same time, both these investigations strongly suggest that the chief storage of iron, copper, calcium and phosphorus does take place in the later months of pregnancy.

In an important series of experiments Wallace²⁶ has recently shown conclusively that the nutrition of ewes during the latter third, but not during the earlier two-thirds, of pregnancy has a marked and important influence on the birth weight and vigour of their lambs and also on milk production. These experiments do not, however, give

any indication of the effect on the offspring of different levels of proteins, metals, vitamins, etc., in the mother's diet.

From our point of view the following is the crucial experiment: when 28 days pregnant a number of ewes was divided into two groups (A) and (B). From the 28th to the 91st day of pregnancy group (A) who were liberally fed gained 33 pounds, but group (B), fed on a restricted diet, lost 11 pounds. On the 91st day of pregnancy a ewe from each group was slaughtered and its foetus weighed and it was found that the weight was the same in each case (1.7 pounds). The rest of the ewes in each group were then divided into two sub-groups (A.1 and A.2 and B.1 and B.2). Group A.1 were kept on the good diet and gained a further 33 pounds during this period and on the 144th day, the end of pregnancy, their lambs averaged 11.3 pounds weight. Group A.2 were changed to the poor ration and by the 144th day of pregnancy had lost 26 pounds and the lambs weighed 6.5 pounds. Group B.1 were given the good in place of the poor ration and gained 56 pounds by the 144th day and the average weight of their lambs was 11 pounds, almost exactly the weight of those in group A.1. Group B.2 remaining on the poor ration lost another 11 pounds, and their lambs averaged only 5.8 pounds. These results clearly indicate that the weight of the foetus depends upon the nutrition of the mother in the last third of pregnancy. Moreover, all the ewes who were well fed during this period developed large udders, while the udders of those which were poorly fed remained small. These results are shown in Table II.

Although the weight of the non-oedematous new-born baby may be regarded as evidence of its state of nutrition, this cannot be accepted for the mother because of the effect of water retention, particularly in toxæmia of pregnancy. Therefore, any attempt to apply Wallace's observations to

TAB. II.

EWES

	(28 days pregnant)		Length of pregnancy	
Groups	A.	B.		
Diet	Good	Poor		
Gain + or				
Loss -	+ 33	- 11		28-90 days
Wt. of foetus in pounds	1.7	1.7		
Groups	A.1	A.2	B.1	B.2
Diet	Good	Poor	Good	Poor
Gain + or				
Loss -	+ 33	- 26	+ 56	- 11
Wt. of foetus in pounds	11.3	6.5	11.0	5.8
Udders	Good	Poor	Good	Poor
				91-144 days

pregnant women must be confined to those showing a small increment in weight; it is also essential to remember that at birth a baby is in a much less advanced stage of development than a lamb, otherwise a most intriguing situation might develop in which the baby rises from its cot, totters somewhat drunkenly across the room, clambers into its mother's bed and demands a feed of breast milk. At any rate, this might solve the problem of breast feeding because I am sure the baby would not go in search of a cow! It is probable that baby monkeys most closely resemble human babies and it is desirable to repeat on monkeys the investigations carried out on sheep and other animals.

It is universally accepted that the nutritional state of the pregnant woman has an important influence on the birth-weight of her baby, but this only becomes clearly obvious when the diet is severely restricted as in famine conditions. Moreover, a well balanced and more than adequate diet may not be absorbed normally and the mother

and foetus may then suffer from a "conditioned" deficiency and not from disease due to deficiencies in the diet. The ideal diet in pregnancy and the effects of diet on the pregnant woman were fully discussed by Nixon in his Blair-Bell Lecture,²⁷ but any attempt to assess the effect of the maternal dietary on the infant bristles with difficulties. According to Young²⁸ reliable data are not available; nevertheless, we must seek an explanation for the decrease during the war years in maternal, neonatal and infant mortality and in stillbirths, and for the diminished incidence of rickets and infantile scurvy. These results are unlikely to be due to better doctoring and nursing if for no other reason than the fact that both doctors and nurses have been few and over-worked. There are certain social differences between pre-war years and the present time, thus:

1. There has been an increase in wages, although this does not apply to the wives of men in the Services.

2. Many mothers have been engaged in industry during pregnancy.

3. The present diet for both mothers and children is almost certainly better than before the war. The rationing system has succeeded in giving everyone a balanced and adequate, although sometimes unattractive, diet, and has provided additional rations of milk and of vitamins A, C and D for expectant mothers and children.

The improvement in dietary is the most likely explanation of the fall in mortality- and morbidity-rates; an explanation which receives considerable support from Baird's work in Aberdeen.^{29, 30} We cannot, however, be absolutely dogmatic on this point because some disconcerting evidence has recently been produced; thus, although it is estimated that 90 per cent of the mothers of this country attend welfare centres, only a relatively small proportion of these accept the vitamin A and D tablets provided for

them if they are pregnant, or the cod-liver oil for their children. An enquiry at certain welfare centres in Birmingham showed that less than 6 per cent of mothers obtained their vitamin concentrates from other sources. Again, A and D tablets were only made available for expectant mothers in 1943; in 1942 cod-liver oil was allowed, but before that date nothing at all, yet the maternal mortality- and stillbirth-rates were considerably less in 1941 than in the preceding 5-year period (1936-1940), although it must be conceded that Baird³⁰ has shown that in Aberdeen the greatest fall in prematurity rates and in deaths from congenital debility has occurred since 1942. We cannot deny that adequate amounts of vitamins play an important part in the nutrition of expectant mothers and in the health and nutrition of the infant, yet in view of the foregoing observations how is the low incidence of rickets and the reduction of the mortality- and stillbirth-rates to be explained? I cannot give the answer but possibly the most important factors are the *extra milk and the improvement in the bread*. It is also noteworthy that in the years immediately preceding the war the lowest stillbirth- and neonatal mortality-rates occurred in well-fed countries such as New Zealand and Holland, and that in Great Britain these rates were the highest in the depressed areas. Besides, even admitting the validity of some adverse criticisms, the investigations carried out in South Wales, Oslo, Toronto, London and Aberdeen lend strong support to the view that the diet and nutritional state of the mother during the latter third of pregnancy affect both the health of the new-born child and the incidence of premature and stillbirths.

2. Immunity.

The full-time, healthy new-born baby has a degree of passive immunity to certain infectious diseases—in particular

to diphtheria and measles—but none to streptococcal, staphylococcal and pneumococcal infections which are such important factors in neonatal mortality. Whence come the antibodies responsible for this immunity? Not infrequently, in the later months of pregnancy, Rh antibodies are found in the blood of Rh negative mothers pregnant by an Rh positive father, and the titre may rise during the last 3 months of pregnancy. Moreover, in the majority of cases of haemolytic disease of the new-born the disease starts before birth and Rh antibodies may sometimes be demonstrated in the circulating blood of such babies at birth. It is also known that the titre of diphtheria antitoxin is as high in the serum of the baby at birth as in its mother's serum and that the cord blood of babies whose mothers have been immunized with T.A.B. vaccine shows a high titre of agglutinins. In all these instances the antibodies must have reached the foetus through the placenta; indeed, the fact that the placenta contains large quantities of antibodies is made use of in the prevention or attenuation of measles by injection of placental extract. In certain animals antibodies, particularly those associated with calf dysentery and lamb scour, are transferred from mother to offspring in the colostrum. This difference in the mode of transmission is due to the structure of the placenta; in the cow it is thick being composed of several layers, whereas the human placenta is thin, the blood actually bathing the chorionic villi and thus rendering transference easy. Owing to degenerative changes the human placenta in the last 3 months of pregnancy becomes even more permeable and organisms as well as antibodies may pass from the mother to the baby. It is said that the transfer of vitamin A to the young follows the same rules and it is also interesting to note that a high titre of Rh antibodies has been found in the colostrum of mothers whose babies suffer

from haemolytic disease, and sometimes these antibodies are also found, but in much lower titre, in breast milk. Although the titre of diphtheria antitoxin in the baby's serum at birth is as high as that of its mother and is not increased by taking colostrum, the transference of some antibodies by the milk seems to be the only possible explanation of the accepted view that breast feeding confers a degree of immunity to the infections of early infancy.

"The evidence is fairly conclusive that an antibody is a molecule of globulin which, during synthesis, has been specifically modified under the influence of antigen." (Cuthbertson.³¹) This globulin is called gamma-globulin, a description which does not refer to its chemical structure but to its movement in an electrical field; in such a field albumins move fastest, and then in order alpha-, beta- and gamma-globulins. As far as I know the amount of gamma-globulin in the sera of premature or full-time babies has not been estimated, but both the globulin and the total protein of the serum of premature infants are lower than those of the full-time new-born child and these, in their turn, are lower than those of older children. (Hickmans,³² Darrow and Cary,³³ Rapaport *et al.*,³⁴.) It seems reasonable to regard the smaller amount of globulin as a factor in the greater liability of the premature than the full-time baby to infection; moreover, if the foetus or baby is badly nourished the "competition for available amino-acids" for purposes of growth may limit the amount of gamma-globulin formed and be one other reason for the liability of such infants to contract infection. On the other hand, the amount of gamma-globulin in the blood may not be a complete measure of the infants' immunity since some of the gamma-globulin may be held in reserve in the tissues of the baby. One further interesting point in this question of immunity in the

new-born is that colostrum contains a higher percentage both of protein and globulin than milk, but in spite of this serum globulin shows the negative phase referred to in regard to other essentials received from the mother *in utero*; in fact it falls until the 4th week, when it commences to rise, reaching the adult level at 4 years.

3. Disease.

In the later third of pregnancy it is possible for organisms as well as antibodies to pass from the mother to the foetus by the placental route. As a result the foetus may be born with an established disease or develop it shortly after birth as, for instance, haemolytic disease, syphilis, septicaemia and rarely toxoplasmosis, tuberculosis, scarlet fever, small-pox. I shall confine my remarks to haemolytic disease of the new-born and to toxoplasmosis.

HAEMOLYTIC DISEASE OF THE NEW-BORN.

Haldane³⁵ has stated that haemolytic disease is responsible for more deaths than any other inherited condition, possibly more than all of them put together, and I want to emphasize that it commences *in utero* and may cause irreparable damage to or even the death of the foetus. I would also stress that sepsis neonatorum may simulate icterus gravis even to the occurrence of kernicterus, and that any or all of the characteristic symptoms of haemolytic disease may be absent at birth; a diagnosis then only being possible by serological tests. It is unfortunate that the number of these appears to increase from week to week, and if Fisher's hypothesis of triple allelomorphs is true, 27 kinds of Rh are distinguishable by serological tests, although some of them only occur rarely; furthermore, to add to our burdens, the possibility that anti-P agglutinins may cause haemolytic disease has recently been raised.

The fact that haemolytic disease starts during foetal life is obvious in hydrops foetalis, its rarest, and in icterus gravis, its most frequent manifestation, but is not so obvious in haemolytic anaemia of the new-born. Both kernicterus and cirrhosis of the liver occur after icterus gravis, but neither has been observed after haemolytic anaemia of the new-born; a condition in which there is only slight jaundice. It is also interesting to note that kernicterus is sometimes found postmortem after an attack of what had been regarded as physiological jaundice. We believe that the kernicterus following neonatal sepsis and that arising from icterus gravis are the result of simultaneous damage to the liver and brain, being, in fact, examples of that curious connexion between the liver and basal ganglia pointed out by Kinnier Wilson when he described lenticular degeneration. It is generally accepted that the cells in the brain which take the jaundice staining are dead and it may well be that the sequence of events is: liver damage; necrosis of cells in the brain; haemolysis; staining of liver and brain cells. By investigating the cholesterol partition in icterus gravis my colleagues Dr. A Rothe Meyer and Dr. E. M. Hickmans³⁶ have produced definite evidence that the liver cells are damaged in that disease and that the jaundice is not simply due to mechanical obstruction from bile stasis; actually it would be difficult to explain the occurrence of cirrhosis of the liver if the jaundice were not due to hepatitis.

In addition to staining of the basal ganglia we have also observed less severe staining of the cortex, a finding which suggests that mental deficiency may result. This suggestion is supported by the mental condition of some of the children who suffer from extra-pyramidal rigidity and athetosis following icterus gravis. Even stronger support has been received from recent work

in which 22 out of 124 random samples of ordinary low grade mental defectives proved to be the Rh positive offspring of Rh negative mothers; a number twice that which would be expected in a random sample.³⁷

Polyostic fibrous dysplasia—a progressive disease of bone associated with pigmentation of the skin and, in the female, with precocious sexual development—was first described as a sequel of icterus gravis by my colleague, Dr. Frances Braid.^{38,39} In our view the association of a number of these cases with grave jaundice is not fortuitous and the sexual changes are probably the result of damage to the cells of the hypothalamus by Rh antibodies.

Sometimes the temporary teeth, particularly the incisors, of an infant who has recovered from icterus gravis, are stained green; in my experience the permanent teeth have never shown such staining, nor have the children shown any evidence of kernicterus or cirrhosis. The enamel of the earlier temporary teeth begins to be formed between the 6th and 9th week and of the later ones during the 4th month of pregnancy and the enamel cells remain active for some weeks after birth. Actually, by the use of isotopes, it has been demonstrated that even fully formed enamel is not metabolically inert; death of the cell is, therefore, in this instance not a pre-requisite for staining.

In icterus gravis liver damage probably always occurs before and possibly also after birth, but I have not the remotest idea why cirrhosis of the liver, staining of the teeth, kernicterus with its sequelae extrapyramidal rigidity and mental defect are not invariably present. Unfortunately, even after the birth of the child, it is impossible to tell whether any of these manifestations will occur, although sometimes one may suspect the existence of kernicterus by a curiously high-pitched cry,

especially if this is associated with convulsions.

The serum of every expectant mother should be tested against the Rh factor, both in her own interest should she need a transfusion after labour and in that of her foetus. This practice is already followed in some clinics. If the mother is Rh negative the father should be tested, and if he is Rh positive the stage is set for the occurrence of haemolytic disease in their children. This may not occur in the 1st pregnancy because the stimulus to produce antibodies is a cumulative one and may not be sufficiently strong in the early pregnancies; I have known its occurrence delayed until the 12th pregnancy. Providing a case of haemolytic disease has already occurred in the family, the father is heterozygous should any of the other children prove to be Rh negative, and then the chances for and against any subsequent foetus having the disease are equal; but if all the children are Rh positive, the father is probably homozygous, in which case the foetus and every subsequent child is certain to have the disease. So far it has not been possible to desensitize the mother or to neutralize her Rh antibodies, but if the baby is given an early transfusion with Rh negative blood its life can usually be saved, although it is doubtful if such treatment will prevent kernicterus or cirrhosis. I myself only advise transfusion if the baby is anaemic, but other people believe that a transfusion should always be given even if this means the previous removal of some of the child's blood. The degree of damage to the foetus varies directly with the time it is subjected to the effects of Rh antibodies and although a definite correlation has not been demonstrated between the titre of these antibodies in the mother's serum and the severity of the disease in the infant, it does seem reasonable, if the titre is rising, to perform Caesarean section or to induce labour as

soon as the foetus is viable. Recovery has followed Caesarean section at the 36th week followed by immediate complete substitution transfusion of the baby with Rh negative blood, but even this does not prove that kernicterus or cirrhosis can always be prevented, although the degree of haemolysis may be limited by the premature birth. Incidentally, this particular child has earned a degree of notoriety since a description of the operation has appeared in the *Woman's Home Companion* and the *Reader's Digest*.

Finally, an Rh negative woman requiring a transfusion for any purpose whatever should always be given Rh negative blood, since Rh positive blood may lead to the development of anti-Rh isoagglutinins although, as with pregnancies, this usually only occurs after repeated transfusions; moreover, Diamond has shown that the most severe forms of haemolytic disease occur in the children of women sensitized by transfusion.

TOXOPLASMOSIS.

Toxoplasma, a protozoan genus, discovered in 1909, is a cause of disease in certain animals and was first shown to affect human beings in 1939. Toxoplasmosis occurs in different forms at different ages, and is sometimes the cause of certain nervous manifestations previously attributed to congenital defect or birth injury (Sabin⁴⁰). In the congenital form, there are four main clinical signs, some of which may be absent: hydrocephalus or microcephaly; choroidoretinitis; convulsions or other signs of involvement of the central nervous system, and X-ray evidence of cerebral calcification. The disease can be transmitted to mice, chickens, guinea-pigs, rabbits and rhesus monkeys. The sera of rhesus monkeys and of human beings who have contracted the disease contain neutral-

izing antibodies which in man probably persist for several years; these afford an important aid in diagnosis since, if a rabbit is injected intracutaneously with a mixture of the patient's serum and toxoplasmatous material, any neutralizing bodies present in the serum attenuate or prevent the lesions of toxoplasmosis which would otherwise develop at the site of injection.

My excuse for discussing this rare disease is that this year I have had in hospital at one and the same time 3 infants who had been infected *in utero*. These cases are the first to be recognized in this country and the credit for this should go to my pathologist colleague, Dr. Baar. The first 2 cases were female twins born in the 32nd week of pregnancy. At birth L. H. weighed 2 pounds 15 ounces and A. H. 2 pounds 8 ounces, and they were admitted to hospital when 31 days old, each then weighing 2 pounds 10 ounces. The skull bones were poorly ossified, the fontanelles widely open and the sutures unclosed, but, except for slight jaundice, there were no signs of disease. After a week L. H. became lethargic, refused food and died 18 days after admission. At autopsy her brain showed hydrocephalus and closely packed lentil-sized granulations in the posterior horn and the middle part of the lateral ventricle. Histological examination revealed an extensive subependymal infiltration with large mononuclear cells which failed to stain with specific stains for astrocytes, oligodendroglia and microglia, and scattered between these cells were tiny spherical bodies apparently toxoplasmata. Animals inoculated with an emulsion of the brain did not show any definite changes when killed 8 to 10 weeks later. An emulsion of the brain of 1 of these animals was injected intraperitoneally into guinea-pigs and when these were killed, 1 animal showed numerous yellowish white nodules about the size of millet seeds in the lungs.

and enlargement and caseation of the mesenteric glands.

In the light of the postmortem findings in L. H., a careful examination was made of her sister's eyes, but evidence of choroidoretinitis was not found, nor did X-ray examination of the skull show any of the characteristic areas of calcification. This child progressed well for 6 weeks, but then developed a fatal pneumonia. An autopsy did not show any choroidoretinitis but did reveal moderate dilation of the cerebral ventricles and a few coarse warty granulations in the lateral ventricles which showed the same histological features as those in her sister. The liver of this child on section showed numerous yellow spots about the size of a millet seed or a pin's head. On microscopy these were found to be areas of miliary necrosis which presented on their periphery an infiltration with large mononuclear cells and lymphocytes and a fair number of tiny spherical bodies like toxoplasma. Animals inoculated with material from the brain of this child showed nothing abnormal.

The 3rd case, D. L., was admitted to hospital when 14 days old because of inability to suck, due, it was thought, to birth injury. This child, which was poorly nourished, weighed 5 pounds 14 ounces. There was an extreme degree of moulding, the occipital overlapping the parietal bones, and the right arm was somewhat stiff and its movements impaired. An X-ray of the skull showed 1 or 2 isolated calcified areas which might be due to toxoplasmosis but are, I think, due to normal calcification. The condition of this child was always unsatisfactory and she died 6 weeks after admission. In the 2 weeks prior to her death she had cyanotic attacks which were accompanied by convulsive movements, but nothing was found to shake the clinical diagnosis of birth injury. At autopsy she was found to have hydrocephalus although ependy-

mal granulomata were not seen, but histological sections showed a sub-ependymal cellular infiltration resembling that seen in the other 2 children. A guinea-pig inoculated with an emulsion of this child's brain died 10 weeks later; its liver and spleen were enlarged and both contained yellowish-white millet seed sized nodules and the mesenteric glands were enlarged and showed areas of caseation. Histologically all the organs involved showed granulomata, necrosis and the presence of toxoplasma.

Both these strains have now been passed through over a 100 animals and always produced the same results. Inhibition of the intracutaneous reactions produced by these strains has been obtained with sulphathiazole and sulphadiazine; with penicillin a weaker inhibition occurred and none with sulphapyridine. Furthermore, positive neutralization tests have been obtained with the serum of A.H. (taken before death and stored) and with the serum of her mother to both strains. We have been unable to persuade the mother of the 3rd child to have the test performed. It is, therefore, certain that Mrs. H. had been infected with toxoplasma and although she had recovered she was a carrier of the disease and infected her babies *in utero*.

Toxoplasmosis can be attenuated in rabbits if sulphadiazine or penicillin is given at the same time as the animal is inoculated but not if given subsequently. Adults have recovered from the disease after taking sulphadiazine but its real value as a curative agent is unknown. We gave it to the 2nd twin but without success; nevertheless, should her mother again become pregnant, it would probably be advisable to give her a course of sulphadiazine or penicillin or both, although the optimal period of pregnancy for treatment and the duration of such treatment would have to be decided empirically.

I have now concluded my lecture and I hope that I have convinced you that both the nature and the nurture of the foetus largely depend on the adequate nutrition and good health of its mother throughout pregnancy, but that even these desiderata will not prevent the occurrence of certain genetic conditions. I trust also that you will agree that the evidence produced has shown that if, owing to inadequate maternal diet or disease the supplies to the foetus are insufficient, especially during the last third of pregnancy, or if, during that time, the foetus is infected *in utero* or is born prematurely, the new-born infant will be immature, lack essential stores and may show evidence of disease or develop it shortly after birth; further, that such a baby is poorly equipped to withstand the trauma associated with labour or to combat the infections to which it may be exposed in the neonatal period.

Great advances have already been made in the prevention of foetal disease and death, but we are not yet in a position to say:

"Never mole, harelip nor scar
Nor mark prodigious such as are
Despised in nativity
Shall upon their children be."⁴¹

Indeed, far too many problems still remain unsolved and success in dealing with them will only be ours when we are completely gripped by a really great urge to achieve it.

"Ah, but a man's reach should exceed his grasp
Or what's a heaven for?"

and a far greater authority than Robert Browning once said, "The Kingdom of Heaven suffereth violence and the violent take it by storm". When obstetricians, paediatricians and social workers combine together in that spirit the future will indeed be radiant with promise. The full results of

such a partnership will not be seen in my life time, but possibly from some Elysian field in company with Blair-Bell I may be permitted to witness them.

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NOTE—Recently Dr. C. M. Wenyon and Dr. A. Sabin (Cincinnati) have kindly examined specimens described as toxoplasmosis in this paper, and both say that the infective agent is not toxoplasma. The disease, therefore, is not toxoplasmosis but an encephalitis which clinically, serologically and by transmission to animals closely resembles it. Investigations are now in progress to determine the nature of the infective agent.

The Toxaemias of Pregnancy

BY

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ECLAMPSIA is a syndrome peculiar to pregnancy, which may be associated with any or all of the following manifestations: headache, disturbance of vision and even amaurosis, vomiting, oedema, a diminished secretion of urine, hypertension, albuminuria, coma and convulsions, while in fatal cases the hepatic and other lesions may present unique characteristics. The syndrome has been recognized for over 2,000 years and, although it occurs in every country, nevertheless exhibits a most marked geographical incidence. Eclamptic convulsions may occur in a woman tormented with headache, bloated with oedema and half human in appearance, whose scanty urine is loaded with albumin, and whose blood-pressure exceeds 200 mm. Hg., and they may also occur in a woman who appears to be in the enjoyment of good health, whose blood-pressure is not elevated, and whose urine is normal in quantity and contains no trace of protein.^{1, 2} Further, the order in which the various signs and symptoms associated with the pre-eclamptic state manifest themselves varies from case to case, although hypertension most commonly precedes all others.³

It may therefore be postulated that any hypothesis which purports to explain the eclamptic syndrome in terms of one or more of its manifestations, no single one of which is inevitably a concomitant of eclampsia, and fails to offer a plausible explanation of all the known facts stands as self-condemned, and however ingenious should be ruthlessly discarded. Further, a sharp distinction should be made between hypo-

thetical mechanisms which seek to explain such manifestations as oliguria, oedema, hypertension and convulsions, and a hypothesis which seeks to explain the genesis of eclampsia. Assuming that it could be proved that eclampsia was associated with placental infarcts, or with hyperactivity of the post-pituitary gland, or with an excess of some chemical substance such as guanidine, histamine, or tyramine circulating in the blood, real advance towards the elucidation of the cause of eclampsia would not thereby necessarily be achieved. It would be almost as logical to assert that pulmonary tuberculosis was caused by cavities in the lung. The real problem would be to determine the cause of the excess of these substances in the blood, why some pregnant women suffer from the toxaemias of pregnancy and others do not; why, indeed, a man should not have eclampsia. Any attempt to reduce this syndrome to such simple terms as a generalized angiospasm would fail to explain well-authenticated clinical facts, and would in any case represent the late mechanism and not the causal agency. In this connexion it would seem that the post-pituitary gland is more sinned against than sinning. Reviews of the literature^{1, 5, 6, 7} reveal the confusion which exists, but it is noteworthy that most of the hypotheses advanced before 1930 have become obsolete.

Practical obstetric experience gained in such diverse centres as London, Cambridge, Dublin, Leeds, and Bangkok, together with extensive travel in the F. I. Near and Middle East, forced me to recog-

nize the remarkable fact that eclampsia manifests a most marked geographical incidence.^{8,9} The incomplete and imperfect vital statistics in Oriental countries make it impossible for this, and much other knowledge, to be garnered in any save a personal manner, but he who ventures to travel beyond his own obstetric parochial boundaries must be prepared to pay a very heavy price. Dieckmann,¹⁰ essayed the task of collecting statistics from many different centres, but it is very obvious that most of them are not comparable. He did, however, show that the incidence of eclampsia varies widely in different centres in the United States of America, and that the syndrome is either unknown, or very rare in Kenya, Uganda, Tanganyika, Persia, Alaska and certain other countries.

It is most erroneous to assume that any facile generalizations can be made, or that it can be asserted that the incidence of the toxæmias of pregnancy is low in Oriental countries, as compared with Europe and America. The incidence of eclampsia would appear to be high in many of the cities of India, whereas all authorities seem to be agreed that it is relatively rare in the agricultural villages, in which 90 per cent of the population lives.

I will here content myself with instancing two remarkable contrasts from my own experience. I cannot recollect seeing any serious case of hyperemesis gravidarum during the 3 years I was at the Rotunda Hospital, although the patients did not receive antenatal care. During 1 year at the Leeds Maternity Hospital a very considerable number of such cases was admitted, and although most of them responded to simple psychological treatment, 1 died and another developed the most severe polyneuritis I have ever seen, being unable to sit up in bed, or even to feed herself. One would hardly have anticipated that dour Yorkshirewomen would have been more

"temperamental" than their Gaelic sisters who lived north of the Liffey.

During my 3 years in Bangkok, a city of some 700,000 inhabitants, I was in charge of the largest obstetric service in the country. It was, in fact, larger than all the others put together. Nevertheless I did not see more than 13 possible cases of severe toxæmia of pregnancy, and 7 of these, who were seen only shortly before they died, might have suffered from acute cerebral malaria, or some other tropical disease complicating pregnancy. I met all the missionary doctors practising in Siam and could hear of only 6 cases in their united experience, which extended over many years. It may also be noted that no system of purdah obtains in Siam, and that neither the Siamese nor the Chinese women evinced any repugnance to entering hospital. In sharp contrast to these remarkably low figures for Siam is the remarkably high incidence of the toxæmias of pregnancy in Ceylon, an island with just over half the population of Siam. The meteorological and living conditions are very similar in both countries, and yet Wickramasuriya^{11,12} reported that the incidence of eclampsia in Ceylon was 28 in every 1,000 live births, perhaps the highest in the world. According to Thiagarajah¹³ this incidence had been reduced to 16.5 per 1,000 live births by 1939, but only at the expense of the pre-eclamptic incidence (including only those women with a systolic blood-pressure exceeding 150 mm. Hg.) which rose during the same period from 32 to 56 in every 1,000 live births.* Yet Dr. Thiagarajah assures me that the incidence of the toxæmias of pregnancy in his own private practice, as in that of his colleagues, is extremely low and

* For every 1,000 live births 120 pregnancies end either in miscarriage or stillbirth, and a further 120 infants die during the first year of life. The figures for India are much worse.

comparable to that which obtains in England.

The inescapable fact that eclampsia manifests a geographical incidence suffices to exclude from further consideration not a few of the hypotheses which have been advanced to explain its aetiology, seeing that by universal consent no micro-organism is causally involved. I was forced, against my will, to abandon Tweedy's hypothesis¹⁴ which received convincing support from the marked success which attended the Dublin treatment of eclampsia. Since factors such as race, hygiene and sanitation could easily be excluded (the personal hygiene and the system of sanitation which obtain in Siam could not be held to be superior to those in Leeds or to differ markedly from those in Ceylon) the inevitable conclusion, so it seemed to me, was that it must be attributed to malnutrition. I confess, after the lapse of more than 15 years, that even after prolonged mental struggle this hypothesis then appeared to me almost as fantastic as it obviously did to those before whom I read the original communication. It nevertheless opened an entirely new and revolutionary approach to the study of the toxæmias of pregnancy.

I restated the hypothesis in 1933¹⁵ in the following terms: "All the ailments and 'toxæmias' associated with pregnancy are caused by an absolute or relative insufficiency of some substance or substances in the diet, the most important of which is calcium, which leads to an inharmonious working of the various physiological processes of the body, and ultimately to hepatic dysfunction. The variety of ways in which hepatic dysfunction may be revealed is only limited by the number of physiological processes in which the liver is concerned." It seemed to me, for reasons which I shall elaborate, that calcium might be the main deficiency, but I stated in my original

paper "whether this suggestion be true or not in no way vitiates the truth of the main hypothesis". The reason these symptoms are peculiar to pregnancy is that the foetus makes nutritional demands on its mother who was suffering from multiple partial deficiencies, both of vitamins and minerals, before she became pregnant.

The purpose of this paper is to make certain observations on the mechanical factors which operate during pregnancy, to examine 2 of the "mechanisms" which have been suggested, (a) hyperfunction of the post-pituitary gland, and (b) placental infarcts, and lastly to evaluate the present position of the dietetic-deficiency hypothesis. Many of the observations will be made in summary form in order to encompass both comprehensiveness and brevity.

With the purpose of attaining precision of criticism, a list of eclamptic postulates is appended, against which any hypothesis may, and should be measured. It states known clinical facts and varies somewhat from that suggested by Whitridge Williams. Any hypothesis which fails to take into consideration a single one of the following facts cannot be considered worthy of acceptance.

The Eclamptic Postulates.

- (1) Its geographical incidence.
- (2) Hypertension.
- (3) Albuminuria.
- (4) Oedema.
- (5) That any 1 or all of these 3 signs (2, 3, 4) may appear independently of the others, and that eclampsia may supervene in the absence of all of them.
- (6) The peculiar and almost pathognomonic lesions associated with eclampsia and conversely, what is equally important, that the liver of a patient dying from eclampsia may present a relatively normal appearance.

(7) The higher incidence of the syndrome in association with primiparity and multiple pregnancy.

(8) The incidence of eclampsia in association with hydatidiform mole.

(9) That a woman may recover completely from an attack of eclampsia and subsequently give birth to an apparently healthy child. Conversely, that postpartum eclampsia may occur many hours after an apparently normal delivery, and apart from any prodromal symptoms.

(10) That death of the foetus is frequently associated with an amelioration of the toxæmic symptoms.

Mechanical Factors, and their Operation during Pregnancy.

Although it is impossible for many reasons to accept Paramore's hypothesis,^{16, 17, 18, 19} which attributes the genesis of eclampsia to an increase in the intra-abdominal pressure, I was nevertheless inspired by his work to pursue certain investigations which led to the following conclusions: (a) that the weight and size of the uterus may be a factor in the causation of albuminuria, oedema, and pyelitis, and (b) that the liver may, in certain circumstances, be seriously damaged by the eclamptic convulsions, and possibly by the uterine contractions during labour.

The Intra-abdominal Pressure.

If an anaesthetized animal be tied on its back, the pressure in the ventral portion of the peritoneal cavity, by whatsoever means it be measured, is less than 2 mm.Hg.^{20, 21} If this pressure be called p , then the intra-peritoneal pressure at any point in the cavity is equal to p + the component of the weight of the viscera acting on it. When the animal is at rest there is no such thing as an intra-peritoneal pressure, for it varies from point to point in the cavity, and the pressure at any one point changes with the

position adopted by the animal. It is only when the diaphragm is fixed (when the breath is held), and the abdominal musculature is strongly contracted, as during coughing, vomiting, defaecation, and parturition, that the pressure becomes so elevated (50-95 mm.Hg.) as to justify the conception of an intra-peritoneal pressure. By the employment of local anaesthesia sterile liquid paraffin (normal saline solution is too rapidly absorbed) may be painlessly introduced into the peritoneal cavity of a dog, and this fluid allows continuous and simultaneous readings of the pressures in the dorsal and ventral parts of the cavity to be obtained. The introduction of a litre of this fluid does not significantly raise the intra-peritoneal pressure, which, it is interesting to observe may fall, wherever measured, below that of the atmosphere while the animal is actually eating food.^{21, 22}

It is very clear that the pressures recorded in the stomach, rectum, and bladder (structures possessing their own musculature), are not those which of necessity obtain in the abdominal cavity. The simultaneously recorded rectal and intra-vesical pressures of a woman at term, while standing upright, correspond very closely, and exceed those similarly recorded in a non-pregnant women by 11.5 mm.Hg. When a woman, whether pregnant or not, bends forward the pressures in the stomach and bladder are thereby elevated, whereas the rectal pressure falls, sometimes by as much as 15 mm.Hg. Drinking a pint of water has no effect on the rectal pressure, but the removal of a pint of urine causes it to fall. Both the rectal and intra-vesical pressures of a woman at term fall to below that of the atmosphere when she is placed in the Trendelenburg, or even in the extreme lateral position. It is therefore evident that the very considerable difference between the rectal pressure of a pregnant woman at term and that of a non-pregnant woman,

when measured in the upright position, must be attributed to the weight of the uterus.²¹

Albuminuria. Urine is a modified ultrafiltrate of the blood-plasma. Ultrafiltration cannot in any sense be regarded as a simple sieving action, but is influenced by the nature and hydrogen-ion concentration of the plasma, the presence of salts, the concentration of protein in the solution, and the filtration pressure.²³ Each human kidney contains some $4\frac{1}{2}$ million glomerulotubular, or ultrafiltration units, and there is reason to suppose that they do not normally all function together, but enjoy rest pauses.²⁴

It has long been known that a number of apparently healthy men from time to time pass albumin in their urine in clinical amounts, that certain foods (especially cheese), cold baths, and exercise may provoke albuminuria, while severe exercise may be associated with the presence, not only of protein but also of blood and both hyaline and granular casts in the urine.²⁵ I have shown that what is true of men is equally true of women, and it has always seemed to me an astonishing, and insufficiently appreciated fact, that albuminuria is more likely to be encountered in healthy college girls than in women who are less than 24 weeks pregnant.^{26, 27}

A distinct variation in the permeability of the glomerular endothelium must be postulated, for during puberty both boys and girls may frequently pass protein in the urine.^{27, 28} This increased permeability of the glomerular endothelium normally disappears before the 20th year, but may persist to a diminished degree for a further 10 years, and even throughout adult life. It may be provoked in 2 ways:

(1) By causing the individual to remain in an extreme lordotic position for from 30 to 40 minutes. Nearly every subject, whether male or female, passes albumin in the urine as the result of this insult, but as

a rule the quantity is small. The individual belonging to the above group, however, passes a considerable quantity of protein. The albumin in all cases comes from both kidneys.²⁶

(2) The ingestion of the whites of 10 eggs in 25 c.cm. of alcohol provokes albuminuria in the individual belonging to the above group, but not in normal subjects.²⁶ The size and weight of the uterus during the last weeks of pregnancy cause the woman to adopt the lordotic position while walking, and thus predisposes her to albuminuria.

Slow, deep breathing maintained for 30 minutes while standing in the upright position, likewise provokes albuminuria.²⁶ The act of respiration facilitates, whereas holding the breath impedes the return of blood to the heart, and thereby raises the general venous pressure. Sprinters hold their breath while running the 100 yards, and a Cambridge undergraduate, who subsequently became a member of our profession, actually ruptured his inferior vena cava while running this distance. It is also probable that this procedure causes a relative anoxaemia, and that both factors are concerned in causing the albuminuria. It may reasonably be assumed that the bulk of the uterus during the last few weeks of pregnancy causes an elevation and relative fixation of the diaphragm, thus impeding the return of blood to the heart, increasing the general venous pressure, causing some measure of anoxaemia, and predisposing the woman to albuminuria.

Contrary to expectation, the raising of the intra-abdominal pressure to 20 and even to 40 mm.Hg. had little or no effect on water diuresis, and did not provoke albuminuria.²²

Pyelitis. A slight increase in the ureter pressure, associated with a low rate of urinary secretion, suffices to increase the dead space between the glomerular tuft and the ureter.²² The weight of the uterus, and

in particular the pressure of the head of the foetus, might be expected to cause dilatation of the pelvis and calyces of the kidney, thus predisposing the woman to pyelitis, if a low rate of urinary secretion is maintained for any length of time. It may also be observed that a slight increase of pressure in the ureter may cause proteinuria.

Water diuresis. If an individual drinks a litre of water under controlled conditions he should pass approximately the same amount of urine within $2\frac{1}{2}$ hours. Should he for the duration of the experiment stand as motionless as possible in the upright position, he will pass little more than half that amount. If, however, his legs and thighs are firmly bandaged before he adopts the upright position, he will pass almost the same quantity of urine as the ordinary subject. It must be supposed that the absence of muscular contractions allows the blood to stagnate in the veins of the legs, and that the increased venous pressure so caused results in the escape of water from the blood-plasma to the tissues.²² Firm bandaging of the legs largely prevents the stagnation of blood and the consequent transference of water. It can hardly be doubted that the weight of the gravid uterus, when the woman is in the upright, or sitting position, likewise causes stagnation of blood in the legs, and consequent transference of water from the blood-plasma to the tissues. This almost certainly accounts for the increase in the ratio of the night/day partition of urine during the latter weeks of pregnancy, which may exceed unity. This constant and abnormal escape of water from the blood plasma to the tissues by day, and its return by night, imposes no inconsiderable task on the mechanism, and should the colloid osmotic pressure of the blood plasma become significantly lowered, or any change occur in the permeability of the capillary endothelium, would result in oedema of the

lower extremities. A certain amount of water retention probably always characterizes the latter weeks of pregnancy.

The Hepatic Lesions associated with Eclampsia.

The evidence would seem to suggest that the typical lesions particularly affecting the liver, which were described by Jürgens,²⁹ Pilliet,³⁰ Schmorl,³¹ Konstantinowitsch,³² and others, were almost invariably found in the organs of women dying from eclampsia up till the end of the 1st decade of this century. Of the sections made from the livers of 44 women who had died from eclampsia in different centres in England and Ireland, which I had the opportunity of studying, only those from 21 cases showed the typical fibrino-haemorrhagic necroses.³³ The older the section the greater was the likelihood of encountering them, and it does seem as if both the clinical manifestations and the pathological picture of eclampsia are changing. Indeed, the fear sometimes obtrudes itself that true eclampsia, like chlorosis, will disappear before its aetiology is discovered. Both Acosta-Sison³⁴ and Davidson³⁵ have reported that the livers of women dying from eclampsia may present a fairly normal histological appearance. The massive haemorrhages of the older sections strongly suggested their possible association with vitamin C deficiency.

It seemed possible that these pathological changes in the liver were caused by, rather than the cause of the eclamptic convulsions. Using a technique³³ which it is unnecessary to describe here, I succeeded in causing severe degenerative and necrotic changes in the liver, sometimes associated with haemorrhagic necrosis in the periphery of the lobules, simply by raising the intra-abdominal pressure in dogs and cats on several occasions to from 60 to 75 mm.Hg. for periods of half a minute. It was not

possible to reproduce all the mechanical factors which operate during an eclamptic convulsion, because the artificial raising of the intra-abdominal pressure causes a marked fall in the arterial blood-pressure.

Strauss and Maddock³⁶ were unable to confirm these results, which they attributed to the minimal amounts of chloroform which I employed. This conclusion cannot be entertained for the simple reason that the pathological changes I have described occurred in an animal narcotized with morphia, and that these lesions were independently confirmed by two eminent histologists. In a letter to me, Dr. Strauss confirmed my guess that his experimental animals had been kept for some time on a well-balanced diet, whereas mine had not. In my view the results reported by Strauss and Maddock add considerable significance to those I reported, and make it reasonable to suppose that a liver, impaired either by imperfect nutrition, or by some chemical agency such as chloroform, may be seriously damaged by the mechanical factors associated with eclamptic convulsions, and even by the "pains" of normal labour. This possibility enhances the difficulty of finding a safe anaesthetic for use during delivery.

It may therefore be asserted with confidence that the weight and bulk of the gravid uterus predispose a woman to albuminuria and oedema in 2 separate ways, and also to pyelitis, and accentuate any other deleterious influences which may be operating in the same direction. It is moreover clear that primiparity, multiple pregnancy, and hydramnios will enhance the operation of such factors, as was suggested by Paramore, although for quite other reasons. It is further probable that both eclamptic convulsions and normal labour pains may damage an already impaired liver, although the intra-abdominal pressure during a convulsion probably does

not exceed that of a normal individual when straining at stool.

Hypothetical Mechanisms.

Most of the hypothetical mechanisms receive their sole support from conjecture, while that which attributes eclampsia to allergy is inherent with its own condemnation.

The Posterior Pituitary Gland.

Hofbauer³⁷ expressed the view that eclamptic convulsions were due to anaemia of the brain resulting from an arterial spasm caused by the vaso-constrictor action of the hypophysis-adrenal system. Anselmino and Hoffmann^{38, 39} were the first to advance experimental evidence in support of this contention. Anselmino, Hoffmann and Kennedy⁴⁰ reported that ultrafiltrates from the blood of both pre-eclamptic and eclamptic patients inhibited water diuresis in rabbits, raised the blood-pressure of anaesthetized rabbits, even when injected subcutaneously, and expanded the melanophores of the frog's skin. Similar results were later published by Chunilal Mukherjee.⁴¹

At about the same time Cushing^{42, 43, 44} advanced the thesis that the hypertension and fits associated with eclampsia could be attributed to pituitary basophilism, associated with a basophilic adenoma of the pars distalis. Siddall⁴⁵ assumed that although vitamin B₁ deficiency normally causes hypofunction of the post-pituitary gland, it exerts the opposite effect during pregnancy, and thereby causes the symptoms of the toxæmias of pregnancy. Lastly, Molitor and Pick⁴⁶ affirmed that if post-pituitary extract be injected intrathalamically it inhibits water diuresis even when amounts are used which have no effect when injected intravenously, and that the inhibition so caused persists for a longer time.

Before summarizing my criticisms of

these experiments I would observe that water diuresis experiments demand an irreproachable technique and infinite patience. The only suitable experimental animal is the bitch, and results obtained from rabbits or rats are apt to be worthless, especially when small amounts of any antidiuretic activity are employed.

(1) Cushing's views no longer claim any general acceptance.

(2) Post-pituitary extract contains but 2 active principles, 1 which is oxytocic, and the other both pressor and antidiuretic. This extract causes an increased output of chlorides and stimulates intestinal peristalsis, whereas the toxæmias of pregnancy are associated with a retention of chlorides, and with coproastasis.

(3) Post-pituitary extract can cause proteinuria, but tends to prevent oedema formation.⁴⁷

(4) Post-pituitary extracts cannot pass through the membranes used by Anselmino, Hoffmann and Kennedy.^{48, 49}

(5) If 10 units of post-pituitary extract be added to normal blood, but little of the activity can be recovered from the ultrafiltrate of the plasma, even when suitable membranes are used. The extract seems to be largely adsorbed to the red blood-corpuscles.

(6) I spent many months in an effort to find evidence of a pressor substance in the blood of eclamptic and other patients suffering from marked hypertension. The blood was withdrawn into a vessel containing the requisite amount of sodium citrate, and surrounded by packed salt and ice in an outside container. The ultrafiltrate was obtained without delay and tested the same day, either on a decerebrate cat, or one under chloralose anaesthesia. This prolonged investigation was most tantalizing, for slight rises of blood-pressure caused by the intravenous injection of the ultrafiltrates tempted one to persist. Fearing that the

pressor activity was being lost, some specimens of blood were collected straight into absolute alcohol at 0°C. Some time later Sir Henry Dale was kind enough to examine my tracings, and expressed the opinion that the recorded rises in the blood-pressure were without significance. These results were to be expected seeing that Høst⁵⁰ transfused 750 c.cm. of blood withdrawn from an eclamptic patient, immediately after a fit, into a patient suffering from carcinoma ventriculi without causing any untoward symptom, or any elevation of the blood-pressure. Page⁵¹ proceeded a step further and transfused 400 c.cm. of blood from each of several patients suffering either from eclampsia or pre-eclampsia, into normal pregnant women without causing a significant rise of blood-pressure in any case.

The truly remarkable ease with which both Anselmino, Hoffmann and Kennedy,⁴⁹ and Chunilal Mukherjee⁴¹ demonstrated a pressor substance in the ultrafiltrates of blood withdrawn from toxæmic patients (some with a blood-pressure not exceeding 150 mm. Hg.), can only be explained on the assumption that toxic changes had occurred in their samples of blood before ultrafiltration was performed.

(7) I did find evidence of antidiuretic activity in the ultrafiltrates of blood withdrawn from eclamptic and pre-eclamptic patients, but reserve my opinion as to whether it was caused by a true antidiuretic substance, or by the almost inevitable toxic changes which occur in shed blood.⁴⁸

(8) I found that minimal inhibition of the diuretic response of a dog to 250 c.cm. and of man to a litre of water, was effected by the intravenous injection of from 0.00005 to 0.001 c.cm. of "infundin".* This means

* A proprietary post-pituitary extract made by Messrs. Burroughs, Wellcome and Co., and standardized in international oxytocic units.

that the intravenous injection of that amount of post-pituitary antidiuretic substance which could effect a concentration of less than one in four milliards† in the blood plasma exerts a measurable effect on water diuresis in a healthy man or woman. Results of the same order were moreover obtained in women in the last weeks of pregnancy.

These profoundly interesting and truly astonishing results raise the issue in acute form as to whether the post-pituitary substance can be regarded as a physiological pressor substance. A careful perusal of the relevant literature reveals but one unequivocal fact, and that is the impossibility of causing a marked elevation of the arterial blood-pressure above the normal, in man or in dogs, by the intravenous injection of post-pituitary extract, for if large amounts are used the blood-pressure falls and death may ensue. The extract, moreover, constricts the coronary vessels and, according to Leschke,⁵³ causes sino-auricular block. The point, however, which I wish to stress is that at least 1,000 times that amount of the extract which inhibits water diuresis must be used to effect a pressor response which is but fleeting. It is impossible to imagine that nature would use the same substance to achieve two widely differing effects, particularly if the one activity demanded a thousand-fold increase of the amount required for the other. It is my view that the antidiuretic substance happens to be pressor when used in non-physiological amounts.

(9) Unlike Molitor and Pick,⁴⁶ I found that amounts of infundin which inhibited water diuresis when injected intravenously, exerted little or no effect when injected

intrathecally. I moreover found that attempts at lumbar puncture, a difficult procedure in the dog, and even the shaving of the skin over the lumbar area, sufficed, not only to inhibit water diuresis, but also to cause proteinuria.⁴⁹ Verney and I⁵² subsequently proved that these afferent sensory impulses inhibit water diuresis when the kidney is completely denervated.

The above evidence makes it abundantly clear that hyper-function of the posterior lobe of the hypophysis could not cause the syndrome of eclampsia. New and most interesting light has, however, been shed on the problem by Shockaert and Lambillon.⁵¹ They reported that if a pressor substance (tonephin†) was injected intravenously into pregnant women, it caused a much greater and more prolonged elevation of the blood-pressure in those patients who manifested toxæmic symptoms than in those who were normal. These important findings have been confirmed by de Valera and Kellar,⁵⁵ and by Browne.⁵⁶ Browne⁷ thinks it possible that these results may be correlated with those of Byrom⁵⁷ who found that both gonadotrophic hormone and oestrogen are capable of sensitizing rats to vasopressin, and also with those of Smith and Smith,^{58, 59, 60, 61, 62} who reported that the amounts of the anterior pituitary-like hormone in the blood serum and urine of patients suffering from the toxæmias of late pregnancy are abnormally high, whereas those of blood oestrin and urine pregnandiol are correspondingly diminished. It is also of interest to note that tolerance can be developed to this extract.⁶³ It is clear that a new field of investigation has been opened up, and that whereas it is reasonable to aver that the syndrome of eclampsia could not be explained by postulating hyper-function

† Post-pituitary extracts some 100 times more potent than the standard powder used for assay purposes have been obtained, so that a concentration of 1 in 400,000,000,000 of such an extract in the blood plasma would suffice⁴².

† A proprietary preparation of the posterior lobe of post-pituitary substance, made by Messrs. Parke & Davis Ltd.

of the posterior lobe of the hypophysis, it is not possible at present to delimit the consequences of hyperactivity of the whole gland.

Placental toxin hypotheses.

Seeing that eclampsia is peculiar to pregnancy any hypothesis which ascribes a causal toxin to the placenta merits particular interest. Stimulated by Veit's work Liepmann,⁶⁴ Freund⁶⁵ and others suggested that it arose in the normal syncytial cells of the placenta, but this view was soon discredited. Quite recently Page⁶⁶ has advanced the speculation that the toxæmic symptoms are due to ischaemia of the placenta, which does not find any support in the observations of Kellar and Sutherland.⁶⁷ The hypothesis, however, which has attracted the greatest interest and won the most support was introduced by Young.^{68, 69, 70, 71} He maintained that both eclampsia and the albuminuria of pregnancy resulted from the absorption of the products of early autolysis of the placenta, which were liberated from recent infarcts "involving more than one-third of the organ and representing, it might be, 10 to 12 ounces or more of placental substance."⁸³ He believed that this conception was supported by the fact that extracts of the human placenta when injected into guinea pigs, caused convulsions, and significant pathological changes both in the liver and in the kidneys. The greatest tribute to the care and skill of his anatomical and histological investigations is afforded by the fact that those of Bartholomew and his fellow-workers,^{72, 73, 74} published after the lapse of nearly 20 years, confirm most of his findings. Whereas Young attributed placental infarctions to some condition which interfered with the maternal blood supply, Bartholomew believes them to result from changes in the foetal circulation. Falkiner,⁷⁵ concluded that the association between

infarcts of the placenta and eclampsia could not be regarded as fortuitous, but unlike Young and Bartholomew did not consider their aetiological significance proved.

Before further consideration of this hypothesis it is desirable to enquire whether there is general agreement concerning the association of placental infarcts with the toxæmias of pregnancy. Whitridge Williams and Stander have persistently denied any particular association. Siddall and Hartman⁷⁶ found infarcts of the placenta in 67.7 per cent of the 700 placentas they examined from consecutive confinements: Haffner⁷⁷ examined 400 placentas and found infarcts in 77 per cent of those obtained from patients who did not manifest toxæmic symptoms, and of these 30 per cent revealed fresh "haemorrhagic foci": von Ravenstein examined 260 placentas and found infarcts in 80 per cent of those removed from patients suffering from albuminuria, and in 66 per cent of those from apparently normal patients: whereas Clements,⁷⁸ after studying 500 placentas, concluded that there was no significant increase in the incidence of infarcts in the placentas removed from toxæmic patients. There seems, however, to be room for doubt as to whether these authors have rightly understood Young's contentions.

The association between placental infarcts and the toxæmias of pregnancy is clearly disputed, and even if it could be proved that they occurred ten times more frequently in placentas removed from toxæmic cases than in those removed from normal patients, it would still be necessary to show why they are not always associated with toxæmic symptoms. It might, moreover, have been supposed that a specific toxin would invariably cause similar effects, whereas the symptomatology of the toxæmias of pregnancy varies notably. It is, further, somewhat difficult to reconcile this hypothesis with the following clinical facts:

(a) that a woman may recover from antepartum eclampsia and subsequently give birth to a living child; (b) that postpartum eclampsia may occur many hours after delivery; and (c) that neither placenta praevia nor threatened miscarriage are commonly associated with toxæmic symptoms.

The significance of Young's experimental work is diminished by the fact that Wooldridge²⁹ succeeded in causing intra-vascular clotting and haemorrhagic necrosis in the dog's liver by the intravenous injection of tissue fibrinogen. Schmorl³¹ repeated these experiments and satisfied himself that he could thereby cause the specific changes in the liver, lungs, kidneys, and brain which he associated with eclampsia. Dieckmann^{30, 31} also obtained similar results from the same procedure. On the other hand I found⁹ that partial separation of the placenta of a pregnant bitch did not cause any toxæmic symptoms.

There is little doubt that toxic products could derive from the placenta, but there is reason to question the causal association of placental infarcts with the toxæmias of pregnancy. The placenta may be involved in physiological disturbances of the maternal organism and possibly plays some part in the reported alteration in the ratio of anterior pituitary-like hormone to oestrin in the blood of toxæmic patients.

In his most recent papers Young^{32, 33} has postulated a "constant and imminent" X factor, or abortion factor, which he suggests may possibly represent a vitamin E deficiency. If he becomes confirmed in this view he will thereby adopt, and add his powerful support to the dietetic deficiency hypothesis. Curiously enough Bartholomew, the other champion of the significance of placental infarcts, likewise supports the dietetic deficiency hypothesis, for he believes the infarcts to result from hypothyroid activity, associated with an excessive

intake of foods with a high cholesterol content. I have for a long time considered it desirable to give iodine to pregnant women, and by this simple means it should prove possible in most cases to stimulate the activity of the thyroid gland.

The Dietetic Deficiency Hypothesis.

All authorities are agreed that no woman requires any article of diet when pregnant that she does not normally need, but that pregnancy demands an increased intake, particularly of the vitamins and of certain minerals. It is manifestly absurd to imagine that any deficiency or deficiencies in the diet could cause any symptom whatever, and it is most obvious that any disease which can properly be attributed to specific deficiencies in the diet is in reality caused by the anabolic and katabolic processes of the body, operating in their absence. Apart from anabolism there can be no deficiency disease. It is undesirable to confuse the argument by enquiring whether the deficiency is due to deficiencies in the actual diet, to errors of absorption, or to inability to utilize the necessary substances.

In animal experiments it has been proved possible to cause barrenness, abortion at different stages of gestation, stillbirths, and the birth of sickly offspring merely by limiting, or withholding a single vitamin from the diet. It is not possible, for various reasons, to demonstrate in man the precise effects of the deficiency or absence of a specific substance in the diet, apart from scurvy and night blindness. Harris, Leong, and Ungley³⁴ express the generally accepted view when they state that conditioned partial deficiencies are likely to be multiple, and that multiple partial vitamin deficiency is not infrequently associated with the poor state of nutrition characteristic of so many diseased states.

I have already referred to the results of

which led me to advance the dietetic deficiency hypothesis of the toxæmias of pregnancy. I have always believed, and have consistently maintained that these toxæmias result from multiple partial deficiencies, and that the most pronounced deficiencies might vary from country to country, and indeed between the different classes in any one community. "A great disservice has been done to the science of dietetics by those enthusiasts who stress this or that vitamin without considering the diet as a whole or the importance of personal hygiene. It is claimed that a complete, well-balanced, appetizing and easily digested diet, rich in the vitamins and in calcium, iron, and iodine, if given early in pregnancy, will prevent the onset of the toxæmias of pregnancy . . . and would increase the resistance of the woman to puerperal infection."¹⁵

There is every reason to believe on the one hand that the activities of the vitamins are to some extent synergistic, so that deficiency of the one enhances the untoward effects of deficiency of another, and on the other, that the operation of each vitamin is depressed by anaemia and ill-health. It is reasonable to assume that pregnancy, occurring in a woman already suffering from the unexposed physiological disadvantages accruing from prolonged multiple partial deficiencies of both vitamins and essential minerals, might be associated with any or all of the following accompaniments: hyper- or hypo-activity of the pituitary and adrenal systems, disturbances in the haematopoietic system, an altered ratio of anterior pituitary-like hormone to oestrin in the blood, hypoproteinaemia, infarcts in, or ischaemia of the placenta, pyrexia, an excess of such chemical substances as guanidine, histamine or tyramine in the blood, or indeed of any other physiological disturbance of the body. The normal temperature, the normal blood-

pressure, the normal water balance, and the normal secretion of urine are each and all dependent on the operation of normal physiological processes which, if disturbed, might result in any abnormal manifestation. "*La fixité du milieu intérieur est la condition de la vie libre.*" I clearly laid too much stress on the toxins absorbed from the gut in my original paper, and have long since modified this view.

Whereas he who supports the dietetic-deficiency hypothesis is naturally anxious to elucidate the mechanism, or mechanisms which ultimately cause eclampsia, and recognizes that they may vary from case to case, the hypothesis itself is not primarily concerned with specific mechanisms, but with the aetiology and prevention of the toxæmias of pregnancy. It may be observed in parenthesis that both scurvy and night blindness were prevented centuries before mankind recognized the existence of vitamins. On the other hand the precise mechanism which immediately precedes eclampsia might be discovered without providing any knowledge whereby the syndrome could be prevented.

As it is now more than 15 years since the hypothesis was first published it is desirable to appraise its present position. In the first place it may be accepted that every antenatal clinic in the civilized world stresses the importance of the nutrition of the expectant mother, whereas in many not only milk, but calcium, iron and certain vitamins are given to those who attend. In the second place it has been accepted by a considerable number of obstetricians in different parts of the world, of whom the following may be mentioned: Siddall,⁴⁵ King and Ride,⁸⁵ Yasunami⁸⁶ (deficiency of vitamin B₁), Mendenhall and Drake⁸⁷ (deficiency of calcium), Strauss,^{88, 89, 90} Bibb⁹¹ (deficiency of protein), Bartholomew and his fellow-workers^{72, 73, 74} (deficiency of iodine), McIlroy,⁹² Nixon⁹³ (general deficiencies),

and, so far as I can gather, Young^{82, 83} (deficiency of vitamin E).

It will be observed that these workers are inclined, for the most part, to attribute eclampsia to a specific deficiency, and a few observations will be made on each of the following deficiencies: calcium, vitamin B, and protein.

Calcium.

So far as my experience went when I first propounded the hypothesis, the incidence of eclampsia varied inversely with the amount of sunshine available to the expectant mother, and my thoughts naturally turned to calcium and vitamin D. Calcium salts form the greater part of the inorganic constituents of the bones and teeth, are present in nearly every tissue of the body, and are essential, not only to many physiological processes but to life itself, for in their absence the blood fails to clot and the heart ceases to beat. The amount of calcium circulating in the blood normally varies between 10 and 12 mg. in every 100 c.cm. of blood, but of this amount probably only 2 mg. exist as calcium ions, while 4 mg. are in some form of combination with protein or lipoids. The foetus demands some 8 g. during the last 4 weeks of pregnancy, an amount greatly exceeding that normally absorbed by the pregnant woman. There is a very delicate, and as yet imperfectly understood mechanism which controls the deposition, blood level and excretion of calcium, and the parathyroids would appear, in some respects, to act in opposition to vitamin D. Widdows⁸⁴ and Matters⁸⁵ agree that the blood calcium falls very considerably during the latter half of pregnancy, and that the placental blood contains a higher percentage of this mineral than the maternal blood. Matters, however, believes that this fall is occasioned not only by the demands of the foetus, but also by

the increase in the amount of follicular hormone in the blood.

In 1928 I had some correspondence with Prof. Paul D. Lamson under whose direction Dr. Minot and Miss Cutler were working on the toxicity of carbon tetrachloride. These workers, while at Johns Hopkins University, had found it impossible to cause visible signs of poisoning in dogs by the oral administration of massive doses of carbon tetrachloride. When the work was transferred to Nashville the dogs died after the administration of less than one sixtieth of the amount of the drug which had had no apparent effect on the dogs at Baltimore. It was subsequently found that the mere addition of calcium salts to the diet made the dogs at Nashville as tolerant to the drug as those at Baltimore.^{86, 87} Estimations of the blood calcium of both sets of dogs were nevertheless almost identical, and remained unaffected by the administration of calcium. The type and circumstances of these experiments do not allow of much room for error. Equally remarkable results were obtained by Greig,⁸⁸ in the treatment of cows suffering from "milk fever", a condition which in many respects most closely resembles eclampsia, by the intravenous injection of calcium gluconate.

It may therefore be postulated that calcium deficiency, even if unreflected by any change in the level of the blood calcium, could account for most, if not all of the toxæmic manifestations. The administration of calcium, if necessary by the intravenous route, almost invariably relieves morning sickness, hyperemesis gravidarum, cramps, excessive salivation, generalized pruritus, and exerts a beneficial effect in the chorea of pregnancy and on other skin rashes.¹³ I started the practice early in 1928 of giving calcium injections to patients suffering from eclampsia, and was satisfied that calcium therapy was of

ful purpose when the damage resulting from its deficiency is too far advanced.

One possible objection to this view is that osteomalacia is not commonly associated with the toxæmias of pregnancy (Green-Armytage and Maxwell, personal communications). This condition is associated with a rapid drain of calcium from the bones to the excretory organs (parathyroid hyperactivity?), and not necessarily with a fall in the level of the blood calcium. It is most probable that the alteration of the calcium phosphorus ratio in the blood is of greater significance than the level of the blood calcium. I am still disposed to think that the most important and common single deficiency which leads to the toxæmias of pregnancy is that of calcium, but maintain as I originally did, that the dietetic deficiency hypothesis is in no way dependent on this view.

Vitamin B₁.

During my stay in Bangkok I was impressed with the fact that the incidence of beri-beri was much higher in pregnant than in either non-pregnant women or men, indicating that pregnancy demands an increased intake of vitamin B₁. I think I was the first to draw attention to this fact and to the possibility that the milder forms of gestational neuritis, wherever they occurred, might be occasioned by deficiency of this vitamin in the diet.⁹ In 1933¹⁵ I reported the successful treatment of a patient suffering from severe peripheral neuritis and manifesting choreic movements, by the addition of vitamins A, B and D together with calcium to the diet. In 1936^{99, 100} I further reported that 4 patients suffering from a mild degree of peripheral neuritis had been completely relieved of their symptoms solely by the addition of from 1,500 to 2,250 units of vitamin B₁ to their diet, but that a further patient suffering from the same

symptoms failed to improve until vitamins A and D were also administered. In 1935 Dr. Audrey Baker suggested that I should co-operate with Dr. Wright and herself in an attempt to determine whether the amounts of vitamin B₁ in the placenta and milk could be significantly affected by the ingestion of large amounts of this vitamin, and whether there was any correlation between the amount of vitamin B₁ in the placenta, the pregnancy toxæmias, lactation, and the development of the infant. This investigation had, for various reasons, to be postponed, but part of it has happily been carried out by Nixon, Wright and Fieller.¹⁰¹ I moreover gave all toxæmic patients at St. Mary Abbott's Hospital from 1933 onwards, 800 units of vitamin B₁ daily, together with other vitamins and minerals.¹⁰² Lastly in the report on the effect of calcium and vitamins A and D on the incidence of the toxæmias of pregnancy I stated that "These results strongly suggest that the other main factor in the prevention of the toxæmias of pregnancy is the vitamin B complex."

I have stressed my interest in the possible association of the vitamin B complex with the toxæmias of pregnancy before criticizing the claims of Siddall,⁴⁵ and more recently of King and Ride⁸⁵ that a "causal relation exists between a deficiency of vitamin B₁ and the occurrence of the toxæmias of pregnancy." Two mechanisms have been suggested whereby vitamin B₁ deficiency might cause eclamptic convulsions; (a) an excess of pyruvic acid in the blood, and (b) hyperfunction of the pituitary gland. The former lacks any serious evidence, particularly as convulsions are not a feature of beri-beri, while the second represents the most specious form of argument, seeing that beri-beri is normally associated with a low blood-pressure.

King and Ride⁸⁵ report that the number of cases of beri-beri complicating pregnancy

admitted to the Hong Kong Maternity Hospitals they visited rose from 49 in 1939 to 155 in 1940, a 3-fold increase. The number of cases of toxæmia of pregnancy rose from 200 in 1939 to 292 in 1940, an increase of 50 per cent. By 1941 the cases of beri-beri had only increased from 155 to 167, whereas the number of cases of toxæmia of pregnancy had risen from 292 to 416. It is thus very evident that both the number of cases of beri-beri and of the toxæmias of pregnancy increased very markedly, although not *pari passu*, during the years 1939 to 1940, and it is reasonably certain that the true incidence also increased, although it has always to be borne in mind that the population of Hong Kong is largely literally floating, and varies greatly.

King and Ride also state that of the 300 cases in which beri-beri complicated pregnancy, only 119 experienced normal pregnancies, whereas the remainder manifested toxæmic symptoms. This evidence, however, does not suffice to establish a causal connexion between vitamin B₁ deficiency and the toxæmias of pregnancy. In the first place the dry type of beri-beri was extremely common in Siam (I saw only 1 of the wet type) and no patient suffering from beri-beri developed any of the toxæmias of pregnancy. In the second place the 119 cases of beri-beri in Hong Kong who passed through a normal pregnancy are far more significant than the 252 who manifested toxæmic symptoms. If vitamin B₁ deficiency were causally associated with the toxæmias how could 119 women afflicted with beri-beri pass through normal pregnancies, whereas eclampsia is so common in Glasgow and other centres in Great Britain where beri-beri has never been diagnosed?

Perhaps the most convincing argument against this thesis comes from Ceylon, where beri-beri is very uncommon. Wickramasuriya^{11, 12} reported an incidence of 28 cases

of eclampsia in every 1,000 live births (an incidence nearly 4 times as high as the peak in Hong Kong); that it was nearly 4 times, and pre-eclampsia 10 times more common in subjects of hookworm disease than in those who were free from this infection; and that it was still more common in women suffering from chronic malaria. Anaemia is the most characteristic feature of both conditions. Haemoglobin estimations were made in 1,119 cases out of 2,741 consecutive admissions to the De Soysa Lying-in Home in Colombo, and of this series the average reading was less than 40 per cent, only 150 giving a percentage of 50 or over.¹³ "The anaemia of ankylostomiasis is typically a secondary anaemia, hypochromic and microcytic in type, but as the disease advances a megalocytic type of anaemia may develop, and later, in the most advanced cases, and aplastic type of anaemia may develop."¹⁰³ Hookworm disease is normally associated with a low blood-pressure, and 90 per cent of infected women exhibit anasarca and albuminuria during the latter half of pregnancy.

A heavy hookworm infestation, even exceeding 50,000 ova per gramme faeces is not, however, incompatible with good health and a haemoglobin percentage only 10 points below normal.¹⁰⁴ Further, some patients may be benefited by the administration of iron, even without removing the parasites.¹⁰⁵

It seems to me that the evidence from Ceylon might be interpreted as proving a causal association between iron deficiency and the toxæmias of pregnancy, and with more reason than that from Hong Kong. It provides in favour of a causal association between these toxæmias and vitamin B deficiency. Anaemia, however, is not universally associated with eclampsia, and it is not always associated with ankylostomiasis. Neither is anaemia always due to iron deficiency, for haemoglobin may be low

demands adequate amounts of vitamins B and C in addition to traces of copper and manganese. Further, the alarming mortality from the malaria epidemic in Ceylon in 1935 was attributed, by those competent to judge, mainly to the malnutrition of the sufferers.

All the evidence goes to prove that the anaemia of Ceylon is a nutritional anaemia caused by the lack of several essential substances, and that ankylostomiasis produces its serious effects only because its hosts are so inadequately nourished. The diet of the poor woman in Ceylon is deficient in all the vitamins and necessary minerals, and it may or may not be of significance that the soil is so poor in calcium that lime salts have to be fed to racehorses and other pedigree animals. I may here mention that Professor N. Mahfouz Pasha in a letter to me states that "the incidence of toxæmias amongst the higher and middle classes (in Egypt) is much lower than among the poor." Baird¹⁰⁶ reports similar conclusions from Aberdeen.

Now King and Ride⁵⁵ state that there was in Hong Kong in 1940 an "almost unimaginable state of overcrowding, malnutrition and distress among the lower classes from which most of our patients are drawn." It would therefore seem most reasonable to conclude that malnutrition was the underlying cause of the increase of the toxæmias of pregnancy in Hong Kong during the years 1940 and 1941, as it is clearly the cause of their high incidence amongst the poor women of Ceylon and Egypt, and that whereas vitamin B, deficiency apparently dominated the picture in Hong Kong, anaemia arrests the attention in Ceylon. This interpretation adds immeasurable significance to both sets of figures.

Although malnutrition is most evidently associated with poverty in Hong Kong, Ceylon and Egypt, it does not mean that

wealthy people in Europe and America do not suffer from malnutrition, which in their cases is the result either of ignorance or of greed. Again the evidence strongly suggests that the incidence of eclampsia fell in certain German cities, not be it noted in the country districts, during the latter years of the first great war. This decreased incidence was associated with a decreased intake of meat and fats, and an increased intake of vegetables, and probably with an increase of physical exercise. It is a matter of opinion whether the increase in the amount of vegetables or the decrease in the amount of meat and fats was the more important factor concerned. There is also some evidence of a less reliable character to suggest that there was an increase in the incidence of eclampsia in Russia during the same years, which could definitely be correlated with an increased incidence of malnutrition.

Hypoproteinaemia.

Starling¹⁰⁷ was the first to demonstrate the significance of the colloid osmotic pressure in preventing oedema formation. It is evident that if the saline osmotic pressure in the tissues rises concurrently with a fall in that of the colloids of the blood-plasma below a critical level, oedema must occur. This tendency would be accentuated by the mechanical factors associated with pregnancy. The marked hydraemia associated with the latter half of pregnancy results in a fall in the colloid osmotic pressure of the blood-plasma, and according to Dieckmann and Kramer¹⁰⁸ the fall is greater in toxæmic than in normal patients. Strauss,^{88, 89, 90} and Bibb⁹¹ maintain that hypoproteinaemia, together with an excessive intake of salt, result in oedema and hypertension. The mechanism Strauss advocates might be the cause of oedema in some cases, particularly since so many obstetricians limit the intake of proteins

because they were so impressed with the evidence that eclampsia was associated with a high intake of meat. I have always maintained that a high animal protein diet can be allowed to patients suffering from the toxæmias of pregnancy provided adequate amounts of vitamins and the necessary minerals are assured.¹⁰² I am equally satisfied that the ingestion of large quantities of meat requires an additional intake of these substances, failing which toxæmic symptoms are liable to manifest themselves. It was a tradition that the Assistant Master of the Rotunda Hospital was called out of the Christmas dance every year to wash out an eclamptic colon. The women of Dublin who entered the hospital with eclampsia before antenatal care was instituted and a low protein diet became fashionable, certainly did not suffer from hypoproteinaemia. Further, the incidence of eclampsia in Australia, where the women probably eat 2 or 3 times more meat than they do in Europe, is high. It must also be remembered that more than half the population of that Dominion resides in five large cities, where vitamins are not so plentiful as on the farms.

There is, moreover, no evidence that oedema *per se* can cause hypertension either during the course of an acute experiment or during the progress of a disease. An acute attack of malignant malaria at the 37th week of pregnancy may cause marked albuminuria, and the daily retention of some 6 pints of water for 3 days apart from any detectable rise in the blood-pressure. It has already been observed that both beriberi and ankylostomiasis may be associated with oedema and even anasarca, and that in both conditions the blood-pressure is usually low. It cannot, therefore, be conceded that oedema causes hypertension, or that an abnormal hypoproteinaemia is the universal accompaniment of the toxæmias of pregnancy.

The evidence in favour of the dietetic deficiency hypothesis may be summarized as follows:

(1) It is difficult to propound any explanation of the geographical incidence of the toxæmias of pregnancy other than that which attributes them to malnutrition, seeing that by universal consent bacteriological agencies can be excluded. The report of King and Ride⁸⁵ from Hong Kong adds additional support to this view.

(2) All animal experiments prove the necessity for an increased intake of certain minerals and vitamins during pregnancy.

(3) Necrosis in the liver may be caused in dogs by feeding them on a cooked lean meat diet,⁹ and in rats by a diet deficient in protein.¹⁰⁹

(4) The mere addition of calcium to the diet of dogs can prevent death from carbon tetrachloride poisoning, while the intravenous injection of calcium gluconate can stop the convulsions, and prevent death from "milk fever," both in cows and in other domestic animals.

(5) It is believed by all authorities that multiple partial vitamin deficiency is common in England and throughout the world. Manifestations of vitamin and mineral deficiencies should therefore become evident during the course of pregnancy, and if the toxæmias of pregnancy do not represent these manifestations then the mother invariably escapes at the expense of the foetus.

(6) This hypothesis alone can satisfy the eclamptic postulates, and it alone promises any hope of preventing the toxæmias of pregnancy.

(7) It receives support from the success of antenatal clinics in preventing the actual onset of eclampsia. It is moreover possible that the marked improvement in the maternal and infant mortality-rates, which occurred in Great Britain between the years 1939 and 1944, may be rightly

attributed to the more balanced diet the poor women were forced to eat. It certainly could not have been due either to an improvement in the medical services or to absence of mental strain.

If, however, the toxæmias of pregnancy are due to faulty nutrition they can be prevented, and if they cannot be prevented the dietetic deficiency hypothesis, however strong be the arguments in its favour, must be rejected. The fact that they can be "cured" or mitigated by dietetic measures, while offering strong corroborative evidence in favour of the hypothesis does not serve to establish it.

Several dietetic experiments have been carried out, and the results will now be considered.

1934.

Mendenhall and Drake⁸⁷ gave 188 pregnant women additional calcium, and of this number only 2 developed toxæmic symptoms. Of the 230 control patients 30 developed toxæmic symptoms. The incidence of toxæmia was therefore 13 times higher in the control group than in that which received calcium.

1937.

Theobald¹¹⁰ requested 50 women, selected at random and not more than 24 weeks pregnant, to take daily: calcium lactate gr. xx, together with capsules containing 11,000 I.U. of vitamin A and 450 I.U. of naturally occurring vitamin D. An equal number of women selected at random served as controls. Seven women in the treated group and 17 in the untreated group developed hypertension (systolic blood-pressure of 140 mm.Hg. or over). Half the number in each group were primigravidae, and among these the incidence of hypertension was 2 in the treated group and 6 in the control group.

1938.

Ross, Perlzweig, Taylor, McByrde,

Yates and Kondritzer¹¹¹ supplemented the diet of 24 primigravidae kept "under the supervision of a competent matron" with certain food substances which included both vitamins and minerals. They concluded that the additional foodstuffs had exerted "no appreciable effect on the incidence of toxæmia."

1941. *The Toronto Experiment.*

Ebbs, Tisdall and Scott¹¹² conducted the following experiment in the Toronto General Hospital, in which 380 women, all of whom were less than 24 weeks pregnant, were divided into 3 groups: (a) those taking a poor diet throughout pregnancy, (b) those supplemented for the purpose of the experiment, and (c) those who normally enjoyed what was considered a good diet. Those selected for the supplementary diet were provided each day with 30 ounces of milk, 1 egg, an orange, 1 viosterol capsule containing 2,000 I.U. of vitamin D, and in addition a weekly ration of 16 ounces of factory tinned tomatoes and half a pound of cheese. Dried wheat germ containing malt and added iron was also given. The main and most striking difference in the results was in the columns for threatened miscarriage, premature birth, and stillbirth, but the pre-eclamptic incidence was not significantly affected by the improvement in the diet. If only these workers had supplemented the diet which they considered good, and compared that group with those patients taking an unsatisfactory diet throughout pregnancy, significant results might have emerged.

1942. *The People's League of Health Experiment.*

This was carried out in 10 London hospitals during the years 1938 and 1939.¹¹³ In each hospital the women who enrolled at the antenatal clinic were divided into 2 main groups. Those in one group received

certain dietary supplements while those in the other served as controls. The women in each group were divided into primi- and multigravidae, and also into age-groups. The daily supplements consisted of: saccharated iron carbonate gr. xviii, calcium lactate gr. xxx, adsorbate of Vitamin B₁ (containing all the factors of the B complex and 200 I.U. vitamin B₁), vitamin C 100 mg., halibut liver oil m. vi. (containing approximately 14,000 I.U. of vitamin A and 800 I.U. of vitamin D), together with minute quantities of iodine, manganese and copper. The figures for the treated group, by whatever standards judged, were more favourable than for the untreated group, but were only just statistically significant in one age-group among the primiparae.

1943.

Browne¹⁶ gave 960 I.U. of vitamin B₁ daily to 100 women during the latter half of pregnancy, and was unable to note any diminution in the incidence of toxæmia as compared with that of a similar number who served as controls.

1938-1944.

During this period I delivered 136 European women, of whom 133 consulted me early in pregnancy. I was able to satisfy myself that all of this latter group had lived on a good diet and were in comfortable circumstances. Many were representatives of the second generation who had lived most of their lives in Ceylon. They were by no means "hardy," but they had lived open-air lives, and co-operated well in any advice they were given. I tried to get them to eat what they liked so long as it agreed with them, to take a light early supper at which they should avoid meat, and to drink as much milk as they could. In addition I asked them to take 1/2 of iodine m.x., and 4 to 6 osto-

calcium* tablets daily throughout pregnancy, and 4 iron plastules† daily for a period of 6 weeks. The results were as follows: Twin pregnancy, 1; placenta praevia, 3; water retention, 1; albuminuria, 0; hypertension, 0 (any pressure exceeding 130/80 mm.Hg. was considered abnormal); Caesarean section, 0. Only 1 case was morbid as judged by the B.M.A. standard. All the infants, with the exception of 2 cases of placenta praevia at the 28th week, were born alive, including 1 case of extensive spina bifida which unfortunately survived operation. Only 1 infant, a Mongolian idiot, subsequently died in its 2nd year. The case of water retention responded to an intravenous injection of Mersalyl, and she has since had 2 normal confinements.

The three women who consulted me late in pregnancy provide a striking contrast. One was completely normal. One, a missionary, who came from England shortly before her confinement was due, developed a systolic blood-pressure of 173 mm.Hg., although her confinement was normal and her infant healthy. Her record shows that her systolic blood-pressure was 140 mm.Hg. 4 years earlier, when she first joined her Society. The 3rd came from India, a primigravida, aged 27. Early in her pregnancy she developed swelling of her feet and ankles, and had been forbidden to take any meat. Vegetables were difficult to obtain where she lived, and she did not take any milk. Ten days after she arrived in Ceylon she gave birth to twins, 8 weeks before they were due. Delivery was rapid and easy, and she appeared to be remarkably well on the following days. Nevertheless, exactly 88 hours after delivery she

* Each tablet contains Vit. D 500 I.U., calc. sacchar. lact. 0.5 gm. and calc. phosph. 0.16 gm.

† Each pastule contains ferri. sulph. ex. gr. v. and yeast gr. 1/4.

developed coma, and later had more than 20 convulsions. If this was not post-partum eclampsia I do not know what it was, seeing that she has enjoyed perfect health ever since. She has not, owing to the war, had any other pregnancy. Both twins are alive.

If I am justified in excluding these 3 patients, then I can report 133 confinements, 132 living babies which survived, with no signs or symptoms of toxæmia other than that of water retention in 1 patient.

DISCUSSION OF THESE RESULTS.

Seeing that I was the first to advocate such experiments I am bound to confess that they have signally failed to establish the dietetic deficiency hypothesis. An improvement in the quality and quantity of the diet may appear to effect a cure in a case of tuberculosis, a disease known to be caused by a specific bacillus, and it is most probable that the same measure might diminish the incidence of infectious diseases. The real value of these experiments is that they indicate the errors which must be avoided in subsequent experiments, and they are:

(1) The "good" diet must be commenced before the onset of pregnancy, and not a bare month before toxæmic symptoms are liable to manifest themselves. It was for this reason that I have reported my results from Ceylon, although the number of cases owing to the war was small, in the hope that similar co-ordinated investigations might be carried out by private individuals in England. It would be most interesting, and might prove very instructive, if data concerning the pregnancies of avowed vegetarians could be published.

(2) There is no reason to suppose that there is any disadvantage in giving vitamins

and other substances in pill form but there is every reason to believe that many, if not most patients fail to take these "pills" regularly, if at all. This may have been the reason why the London investigation, clearly the largest and best planned of all these experiments, so clearly failed to provide any significant results. The women were given far too many "pills", some of which are indubitably prone to cause indigestion. This may also be the reason why the best reported results were achieved merely by the addition of calcium, with or without vitamins A and D to the diet.

(3) It is illogical to include multiparae as such in the experiment, because previous experiments have already separated them into 2 clearly defined groups, those that have, and those that have not manifested toxæmic symptoms. Providing accurate and comparable records of previous pregnancies are available, those that have manifested toxæmic symptoms may be divided into 2 groups, the one to receive additional foodstuffs, and the other to serve as controls.

(4) Browne⁷ referring to the statistical report I published,¹¹⁴ writes: "The old's contention has never been adequately answered and must be taken as incorrect. The only convincing explanation of his findings is that those women who develop hypertensive cardiovascular disease after toxæmia were originally predisposed to it, and would have developed it even if they had never become pregnant." This view is supported by Isenhour⁸, Barnes and Browne.¹¹⁶ Vignard¹¹⁷ concludes that the toxæmic diseases are associated with original endocrine stigmata. Classical eclampsia occurs more commonly in pregnancies and is not likely to recur in subsequent pregnancies, whereas the hypertensive toxæmia tends to manifest symptoms earlier in each successive pregnancy. The Tr

question is whether the hypertensive, doomed to this condition, so far as we know, from the cradle, belongs rightly to the category of toxæmias of pregnancy. It may be that eclampsia represents the rapid and intensive operation of those factors which over a long period of years cause hypertension and Bright's disease.* It may be that hypertension, both in the pregnant and non-pregnant state may be prevented by adequate nutrition. Antenatal investigations may indeed do much to solve the riddle of cardio-vascular-renal pathology, but in the present imperfect state of our knowledge both groups should be kept distinct.

CONCLUSION.

An impartial examination of all the available evidence makes it difficult to resist the conclusion that the toxæmias of pregnancy are the result of an excessive drain by the foetus on inadequate maternal nutritional stores, aggravated by the untoward mechanical factors inseparable from pregnancy. The hypothesis has neither been established nor, for reasons which I have given, refuted by the direct experiments which have been reported. Seeing that this hypothesis alone offers hope of the elimination of the toxæmias of pregnancy it is of the utmost importance that further co-ordinated attempts should be made, either to establish its truth or to expose its fallacies. The death of a woman in the very act of fulfilling the highest destiny for which nature has fitted her is a peculiarly poignant tragedy, but the significance of the hypothesis to the race is of far greater import.

Although an eclamptic patient may give

birth to a healthy infant, all authorities are agreed that a great wastage of foetal and neonatal life is directly attributable to the toxæmias of pregnancy. In my original paper¹ I claimed that "it is probable that human abortions, for the majority of which no adequate explanation can be offered, may be caused by deficiencies in the diet." There is, moreover, evidence which I will not elaborate, to suggest that foetal abnormalities, monsters, and hydatidiform moles may result from imperfect nutrition during the first 12 weeks of intra-uterine development. We have Browne's authority² for the statement that Ballantyne introduced antenatal care with the avowed purpose of preventing foetal abnormalities, and only towards the end of his life resigned himself to the conclusion that he could but benefit the mother. The wheel of fortune has turned a full circle, and evidence obtained from caring for the mothers has opened up possibilities of benefiting the foetus which exceed Ballantyne's wildest hopes.

The obstetrician is thereby not only thrown into closer co-operation with the paediatrician, but becomes closely associated with, almost affiliated to the Public Health services. The renaissance of obstetrics in Great Britain, attributable largely to the activities of the Royal College of Obstetricians and Gynaecologists, has made it all the more evident that the improvement in the maternal, foetal and neonatal mortality-rates in Great Britain could not have been accomplished apart from, and is in large measure due to these services. It is very clear that the prevention of ankylostomiasis and malaria will contribute more to the reduction of the maternal and foetal mortality-rates in Ceylon than any extension of the maternity services. The same observation would apply to India, China and many other countries.

The final elevation of the dietetic deficiency hypothesis to the theory of the

*The "ontogenesis" of eclampsia may represent a swift recapitulation of the "phylogenesis" of Bright's disease!

Encymonic Atelositeses* might make it possible, not only to eliminate the toxæmias of pregnancy, but also to lower the incidence of puerperal sepsis, reduce the abortion, stillbirth- and neonatal death-rates, and perchance to reduce the incidence of foetal abnormalities and monsters, and even of twin pregnancies and placenta prævia. Defective spermatozoa may be as associated with malnutrition as is contracted pelvis, and the "vital rubber" with which each child is endowed is in large part as dependent on the state of nutrition of the germ cells of its parents as on that of its mother during its intra-uterine existence. The penalties of nutritional defects are assuredly visited on the children unto the second and third generation.

England to-day is suffering sorely because the flower of her manhood was mown down on the blood-stained fields of Flanders more than 25 years ago, and that irreparable loss has been intensified by the staggering load of toil and sacrifice of the last few years. The country is tired mentally and physically and faces an unknown and difficult future. Babies are a priceless heritage which are needed as never before in our long history. Not one must be wantonly lost, and not one must be brought into the world without the endowment, both of the maximum vitality that its parents can impart, and the necessary environment, which in many cases the State alone can provide. The greatest single means of attaining these ends is to afford each individual an adequate supply of proteins, carbohydrates and fats, together with the necessary complement of vitamins and

minerals. Who can foretell the diseases which will disappear from our ken if these ends are attained?

SUMMARY.

(1) The dietetic deficiency hypothesis postulates that the nutritional demands of the foetus on a mother suffering from multiple partial deficiencies, both of vitamins and essential minerals, deficiencies which usually antedate the pregnancy, are the underlying cause of the toxæmias of pregnancy.

(2) The bulk and weight of the pregnant uterus predispose the pregnant woman to albuminuria, oedema, and pyelitis, and accentuate the activities of deleterious influences operating in the same direction. Primiparity and multiple pregnancy enhance the operation of these mechanical factors. It is further possible that the eclamptic convulsions, and even the "pains" of normal labour may damage an already impaired liver. This possibility increases the difficulty of discovering an absolutely safe anaesthetic for use during delivery.

(3) In Siam, with a population of some 11 millions, when antenatal clinics hardly existed, and public health activities were in their infancy, eclampsia was all but unknown. In Ceylon during the same period the incidence of eclampsia almost certainly exceeded 28 per 1,000 thousand live births. In Hong Kong the incidence of the toxæmias of pregnancy increased by over 100 per cent between the years 1939 and 1941, and was associated with an evident increase in the numbers suffering from malnutrition.

(4) A clear distinction should be made between mechanisms which are thought to cause toxæmic symptoms, and hypotheses which purport to explain the genesis of eclampsia. Of these mechanisms two have won the greatest measure of support. The

* Atelositesis denotes a state of nourishment which is imperfect either quantitatively or qualitatively (or both quantitatively and qualitatively). Mr. Cuttle could not think of Latin words which would be equally descriptive and for this reason "encymonic" must be employed rather than "gestational."¹⁰²

one attributes the toxæmic manifestations to hyperactivity of the post-pituitary gland, the other to the toxic autolytic products which derive from recent infarcts in the placenta.

(5) Reasons are given to show that hyperactivity of the post-pituitary gland could not cause the manifestations of eclampsia, and to suggest that post-pituitary extract does not contain a physiological pressor substance.

(6) Although the autolytic products of the placenta are undoubtedly toxic, the available evidence suggests that the toxæmias of pregnancy cannot as a rule be attributed to placental infarcts.

(7) If it be true that hypertension is as common in single as in married women who have borne children, and that a number of women who suffer from hypertension during pregnancy would have developed it whether or not they had become pregnant, then it clearly follows that such women should not be classified to any of the columns of the toxæmias of pregnancy. It may well be that adequate nutrition might prevent the development not only of hypertension, but also of the cardio-vascular-renal sequence which ends in Bright's disease, but in the present state of our knowledge the confusion of "essential" hypertension with classical pre-eclampsia can but obfuscate the issue and impede the efforts to elucidate the cause of both conditions.

(8) The dietetic deficiency hypothesis alone satisfies all the eclamptic postulates. The evidence in its favour, and in particular that afforded by the geographical distribution of the toxæmias of pregnancy, appears to be very strong. Nevertheless its proof awaits the satisfactory demonstration that they can be prevented.

(9) Suggestions are made as to why the dietetic experiments so far made have signally failed to establish this hypothesis,

the most important of which is that the "good" diet must be given before pregnancy commences.

(10) The saving of maternal life which would result from the elimination of the toxæmias of pregnancy would be great, but the consequent saving of foetal and neonatal life would be of immeasurably greater significance, for good or for ill, to mankind.

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The Obstetrical Forceps: Controlled Axis Traction

BY

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MUNRO-KERR¹ describing the forceps operation writes:—

“The amount of traction which can be exerted by the forceps, especially axis-traction forceps, is enormous, because, if well applied, the blades grasp the head so exactly. It is this perfection of design which makes the obstetric forceps such a dangerous instrument in the hands of the inexperienced and the aggressive accoucheur, who does not appreciate his own limitations and the limitations of the instrument. I have seen an accoucheur with his feet up against the couch, even applied to the buttocks of the patient, exerting all his strength. I have occasionally exerted a considerable amount of force myself, although I believe this is seldom justifiable. The instrument is, then, as a rule, being used in a wrong manner, or too early, or is unsuitable in the particular circumstances.” Some years ago Sir Comyns Berkeley² offered the criticism that women might very well pray “*From the obstetrical forceps, good Lord, deliver us.*” It must be recognized, however, that just so long as the forceps operation is dependent on individual judgment, disasters are inevitable and the obstetrical forceps will continue to take their toll of life and well-being. The instrument is not infrequently used under conditions which require the application of what most authorities describe as “tentative traction,” the implication being that the use of force beyond the tentative will result in stillbirth and serious injury to the mother. Unfortunately the estimation of tentative traction depends

entirely on individual judgment—a peculiarly human faculty subject to the variation and error of all human attributes. Yet there can be no greater betrayal of the scientific method than resort to the force described by Kerr, for if delivery is possible with brute strength it can always be more safely accomplished by knowledge and art.

Can we put a limit to the force which can safely be used in a given case? With experience of controlled traction it seems possible to acquire a knowledge of the limits to which the traction force can safely be raised.

MEANS OF CONTROLLING TRACTION FORCE.

The idea of measuring traction force is no new one, and rather cumbersome instruments were devised by the earlier French obstetricians who were chiefly interested in the amount of force necessary to effect reduction in the diameters of the foetal head in cases of disproportion.

The included diagrams show the construction of instruments which have been found to give accurate control of traction force. They are adequately represented in the illustrations and require little more description. The springs in each are of stainless steel and their temper is not affected by boiling. Both instruments are chromicized so that they can be boiled without fear of corrosion. The round spring handle—Figs. 1 and 1a—can easily be dismantled and reassembled and is a very simple mechanism. The coach-spring handle, Fig. 2, does not have any detachable parts, and

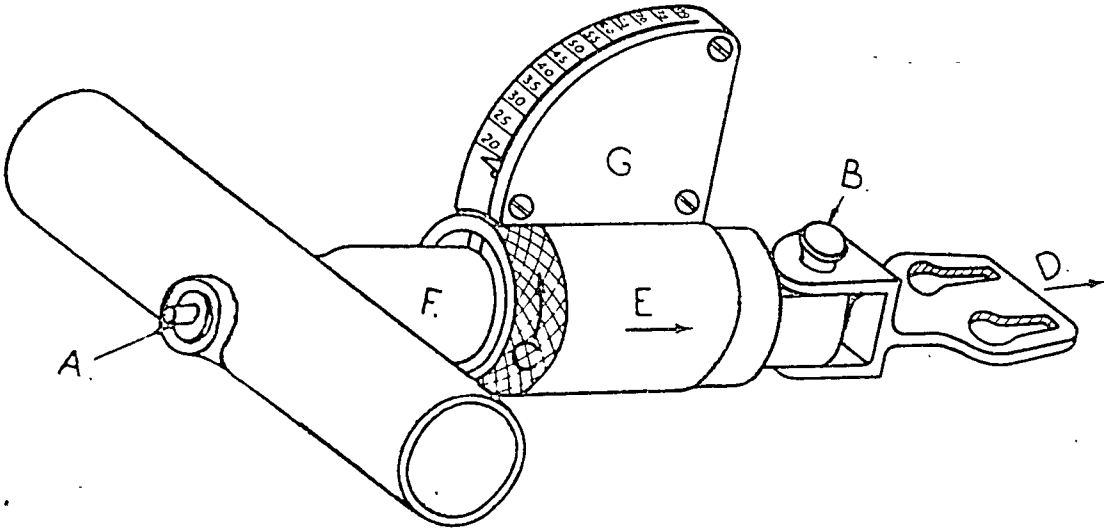


FIG. 1.

Traction handle No. 1. Spiral spring type.

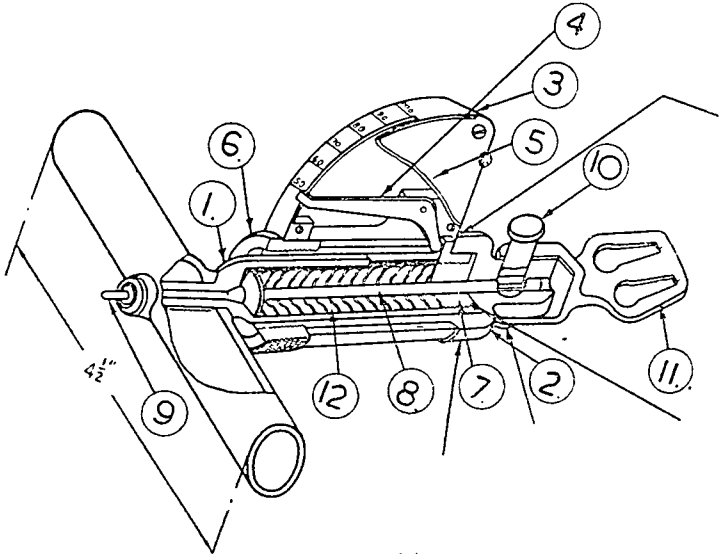


FIG. 1 (a)

Traction handle No. 1. Spiral spring type, casing partly removed.

Part No.	Description	Part No.	Description
1.	Handgrip and inner sleeve.	7.	Screwed plug in inner sleeve.
2.	Outer sleeve and eyelet piece connexion.	8.	Pre-loading spindle.
3.	Scale case and band.	9.	Pre-loading push rod.
4.	Indicator.	10.	Pre-loading maintaining pin and pivot.
5.	Scale case cover.	11.	Eyelet piece.
6.	Knurled nut on outer sleeve.	12.	Spring.

Initial Loading Rod. Push rod with conical end is used for compressing spring to initial load of 50 pounds. When push rod is pushed in, pivot pin (10) is pushed up until edge of hole through pin engages with recess in pre-loading spindle, thus maintaining compression.

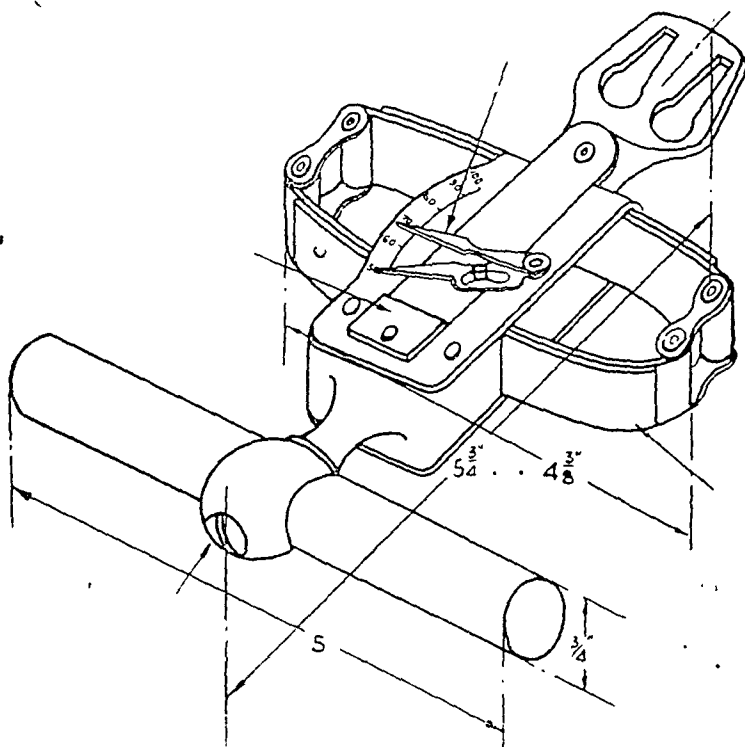


FIG. 2.

Traction handle No. 2. Leaf spring type.

requires no more care than the solid handle. There is some advantage in keeping the distance between the traction bar and the connecting link as short as possible but it has not been possible to maintain this, and both instruments are about 2 inches longer than the orthodox handle. Calibration of the recording scale is accurate but requires checking from time to time although variation in the recording mechanism is most unlikely, even over long periods of time, if the instrument is made from good metal and expertly fashioned. As will be shown below there is no necessity to record forces below 50 pounds, except as a matter of interest. Similar traction handles could be designed for any type of forceps.

In use, one finds that the traction force is applied slowly to the head and the im-

pression is gained that the same power cannot be used as with the solid handle. This, however, cannot be the case since the same force is required by either instrument to effect delivery, and the apparent loss of power is simply due to the fact that, with the spring handle, the force is more slowly and therefore more safely raised. With experience this feeling of loss of power disappears and is replaced by one of confidence.

It is doubtful if even the expert technician can guess to within 20 pounds the force which he employs, although we have it on good authority that the expert technician should never guess. It is probable that many never think of traction in terms of measured force at all nor do they relate it in any definite way to the compression

force applied to the foetal head. The accoucheur simply gauges the resistance to descent against his pull and frequently he will attempt a little more force than is compatible with absolute safety.

Experience is the only guide in these cases and as Franklin³ puts it "Experience keeps a dear school but some people will learn in no other, and scarcely in that." It is very doubtful if any single traction effort can be raised slowly and smoothly without visual control, for even when that control is supplied it is only with practice that the pull can be gradually increased. The "cushion" effect of a spring introduced between the traction force and the resistance makes it impossible to apply a sudden "jerk" to the head or to use any more force than is necessary to its descent. This is, in itself, a great advantage.

There is little point, however, in measuring traction force unless it can be related to the compression of the foetal head and the distension of the genital canal. It is impossible, at present, to reproduce experimentally the forces acting on the foetal head during any phase of labour and it is particularly difficult to arrive at any estimation of those components which are supplied by the resistance of the birth canal itself. The traction force is determined wholly by the resistance to descent of the head, the greater the resistance the greater the pull, and with the forceps applied to the sides of the fully-flexed head, the force compressing the foetal skull will bear a more or less constant relation to the traction force. Delors⁴ estimated the compression force to be one half of the traction force but does not give any details of how he arrived at this estimate. For the purpose of estimating the traction force that can be applied with safety to mother and foetus, it is unnecessary to know either the maternal resistance or the amount of the compression force involved although a know-

ledge of these would greatly ease the solution of what is, perhaps, at once the most difficult and the most important problem in the mechanics of labour. Moreover, there is considerable variation in the capacity of different foetal skulls to withstand compression. It has long been known that the premature head does not readily withstand compression, and prematurity is always a contra-indication to forceps delivery. Holland,⁵ discussing the stresses and strains to which the foetal head is subjected during labour, writes "It is impossible during the course of labour, in any given case, to analyze the exact nature of cranial stress and to measure accurately its intensity or to predict its effects." Nevertheless it is possible to demonstrate a definite relation between the traction force and the force compressing the foetal head and to arrive at an approximation of the maximal force which can be exerted on the forceps with safety to mother and infant and beyond which stillbirth and severe maternal lacerations would seem inevitable. This statement is qualified by the following requirements:—

- (1) That the foetus be an average full-time one weighing between 7 pounds and 8 pounds.
- (2) That the head be fully flexed and the long diameter brought anteroposteriorly.
- (3) That the forceps be applied to the sides of the head.

FOETAL DEATH AND COMPRESSION FORCE.

The work of Holland on intracranial foetal injuries during labour is among the classical contributions to obstetrics. He regards "The septa of the dura mater as ligaments of the bones of the vault restraining excessive alteration in the shape of the head during labour. When the head is subjected to excessive stress the strain thrown on the septa may be so great that

they tear." Holland admits that it is impossible to assign the exact cause of death in those cases. Tearing of the septa is unlikely by itself to cause foetal death and in fatal cases is associated with rupture of blood vessels, compression of the vital centres and consequent anoxaemia. The foetal heart may continue to beat after the vital centres have ceased to function. This it does by virtue of its own inherent rhythmic activity. The tearing of the septa must be regarded as the result of excessive force but the point to be determined is whether this occurs before or after the lethal effects of compression are produced. Compression effects are often in evidence in the absence of actual tearing and it would seem to be a fair inference that a force less than that necessary to effect rupture of the septa may still be sufficient to cause foetal or neonatal death.

If sections of dura mater, 1 inch square, are removed from the recently dead full-time foetus the tensile strength of the membrane can be measured in different directions of tension. The sections tested were removed from the dura mater underlying the parietal bones. In the anteroposterior direction rupture occurred with an average force of 10 pounds, in the transverse direction it occurred with an average force of 7 pounds. The falx cerebri is comparatively fragile and will not withstand a tension force greater than 2 pounds in any direction. The tentorium cerebelli was not tested.

The maximal tensile strength of any section of dura tested was 13 pounds in the anteroposterior plane and in this instance the foetus weighed 8 pounds 8 ounces. It has not been possible to compare the tensile strength for different weights but the impression has been gained that the strength of this membrane is related to weight, being stronger in the heavier infant. The falx shows remarkably little variation although

it is likely that, as Holland points out, it is stronger in some parts than in others. Regarded from the point of view of a ligament supporting cranial stress it must be held that its strength is determined by its weakest part. The sections tested were cut from that portion which lies between the two cerebral hemispheres and the two fontanelles. On removal they were immediately placed in saline and were kept moist during the whole period of testing. Fixing in the clamps was facilitated by immersing each section in saline in a watch-glass and spreading with forceps, the forceps picking up only the cut edges. If the section tore along the line of clamping it was discarded and only when rupture of the fibres occurred somewhere between the clamps was the result regarded as representing the breaking strain.

If we assume that a force delivered at the periphery of the skull is reduced or absorbed, as it were, by moulding to a force less than 7 pounds before it is communicated to the dura, and to less than 2 pounds, before impinging on the falx, then it would seem that in normal labour the foetal skull is so adapted to absorb normal compression force that the actual brain substance largely escapes pressure and this is exactly what we would expect.

It is recognized that these forces are not strictly comparable, for one is in terms of compression and the others in terms of tension, but having regard to the mechanism of moulding and the intimate relation between the two forces this comparison would appear valid. In normal labour the incidence of the compression forces is in the main upon the girdle of contact, that is, in the suboccipitobregmatic circumference, and a compensatory elongation of the mentovertical diameter takes place. It is likely that this elongation is directly proportionate to the compressing force, but in any case the measurement of this force is

not absolutely necessary for our purpose because we know that, when the limit of safe moulding has been reached, the strain falls on the falx, and that this structure offers a practically negligible resistance. In consequence of these facts we cannot but assume that, in normal labour, whatever compression force is exerted on the foetal skull must be completely dissipated in the movements of elongation and moulding and within a certain limit, for if the force continues to act beyond this limit its magnitude need only be very small to effect rupture of the falx. Rise of intracranial pressure probably begins when the limit of moulding has been reached, and in the interval between this event and the rupture of the falx the foetus may die. A factor which must be considered is the elasticity of the falx, and in cases in which this is very great, compression and death may be effected without rupture. There is no evidence to indicate that rupture of the dural septa may not be uncommon and compatible with survival, but it is significant that scarring of the septa has not been reported as a feature in the pathology found at autopsy in infants. The tension which intracranial structures are able to support forms some index of the limit of moulding and of these, the falx offers most likelihood of accurate measurement.

The skull responds to the compression force by altering its shape, but, when the limits of this alteration are reached, the force is communicated to the brain itself and here the impact of a force equivalent to something less than the tensile strength of the falx is apparently sufficient to cause foetal death. - It is unlikely that the dural septa can have any marked effect in restraining moulding of the skull and it is probable that they merely divide the cranial cavity into compartments for the subdivisions of the brain.

The structure of the foetal brain is such

as to allow it to follow easily the alterations in shape of the protecting skull. The lining membranes and blood vessels show great accommodation to tension before actual rupture, but the delicate nature of many of these structures, particularly the pial blood-vessels, suggests that interference with their function would be accomplished by a very small compression force and it may be that anoxaemia is the important factor in producing death. The work of Chute and Smyth⁶ shows that brain tissues have a very rapid gaseous metabolism and that interference with the blood flow through the brain rapidly checks its function. It is probable that this effect has been reached before the tearing of the septa and the gross haemorrhagic lesions which are sometimes found at autopsy.

In stillborn cases of breech presentation where the aftercoming head has been delivered with difficulty the writer has found few macroscopic lesions. Microscopically the outstanding feature was that almost all the capillaries in the brain, especially in the medulla, pons and cerebellum, were distinctly engorged. The veins were also distended almost to rupture, and in slightly varying degree. In certain areas rupture had occurred with local extravasation, rhexis and local haemorrhage. Where the areas involved were relatively large the blood tracked along the perivascular spaces and in some instances reached the subarachnoid space where meningeal vessels showed similar changes. The cause may have been trauma and compression and partly lack of oxygen. Holland found that haemorrhage was always confined to the area drained by the vein of Galen and its tributaries and he believes that the rupture of the vessels is due to tension and engorgement.

The evidence suggests, however, that foetal death is produced by comparatively small compression forces reaching the brain

and that gross lesions are the results of these forces continuing to rise after death.

THE EXPERIMENTAL PROBLEM.

If the moulding of the foetal skull provides a mechanism whereby normal compression force is absorbed and prevented from reaching the brain, and, if only a small compression force applied to the brain is required to produce foetal death, it follows that by determining the force, which, applied through traction to the skull, first appears within the cranial cavity, we arrive at an approximation of the maximal safe traction force. The measurement of this force is scarcely practicable in the labour room and one must have resort to methods of experiment which are not without fallacy. Nevertheless they reveal interesting information and substantially support the belief that a knowledge of the traction force alone can be a safe guide in forceps delivery.

In each experiment a full-time normal foetus, weighing between 7 pounds and 8 pounds, was used. Death had occurred during labour or soon after delivery and from such cause as prolapsed cord or other condition not associated with extreme moulding of the head. A foetus born by Caesarean section provides the most reliable experimental data. The time elapsing between death and the experiment was only a few hours at the most. A wide-bore needle was introduced into the cerebrospinal canal in the lumbar region and its entry into the canal verified by withdrawing a little cerebrospinal fluid. The body of the foetus was then placed on a small platform so that the head hung down, over and behind a vice. Clamped in the vice was a ring of stout rubber with a central aperture 4 inches in diameter and the outside wall reinforced with an angle iron to allow clamping in the vice. Fixation of the head during powerful traction was at first a difficult problem

until a small rubber tyre was found to suit the purpose admirably. The forceps was applied to the sides of the head and the head gently drawn into the aperture until resistance was encountered. The position of the needle in the cerebrospinal canal was again verified, and the needle then connected with a water manometer which was fixed with the water level approximately the same as the point of entry of the needle into the canal. Since the cerebrospinal fluid is not under initial tension, and displacement of the water only begins with application of the traction force, it is important that the same position of the manometer relative to the foetus be observed in each case if comparison is to be made accurately. Traction was now begun and the force gradually raised (Fig. 6).

The traction handle for this work was improvised from a Salters No. 20 spring balance. All unnecessary appendages were sawn off the iron box containing the spring. A connecting link was fixed with a small nut and bolt to the spring lever and a U-shaped bar riveted to the sides of the box so that the handle bar passed behind and equidistant from either end allowing a comfortable, powerful grip. The scale of this balance is marked off in 1 pound units and registers up to 100 pounds. This particular improvisation has been used in the labour room and although it has been frequently boiled is still accurate.

The traction force was raised by increases of 10 pounds at a time, the traction being maintained at each level until the water column in the manometer became stationary. The reason for doing this is described below.

Only 1 foetus, stillborn by Caesarean section, was available for study. Pulsation was present in the cord when extracted and the indication for section was placenta praevia. This foetus weighed 8 pounds 8 ounces, but is included here to show how

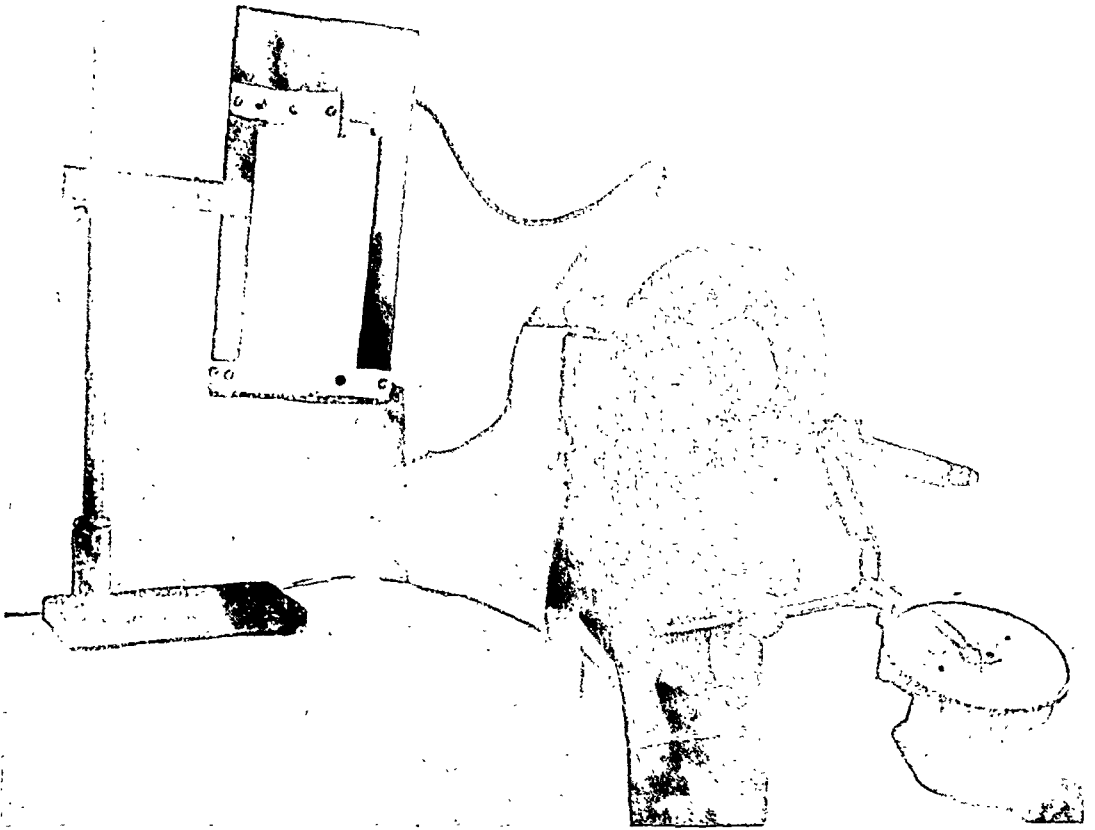


FIG. 6.

Experimental method of recording compression effects of traction force. A few slight alterations have been made for pictorial purposes. The improvised resistance consists of a rubber tyre with an inner circular iron bar. The resistance can be increased when necessary by the use of rubber wedges. Note the traction handle. The large spring and scale of this instrument allow a very fine control over traction force.

J.B.

traction force may affect the completely unmoulded head. As the traction force was increased from 0 up to 60 pounds the water in the manometer rose slowly; thereafter it rose more rapidly with each successive rise in force until between 90 and 100 pounds when it became stationary. This rising intracranial tension is shown graphically in Fig. 3.

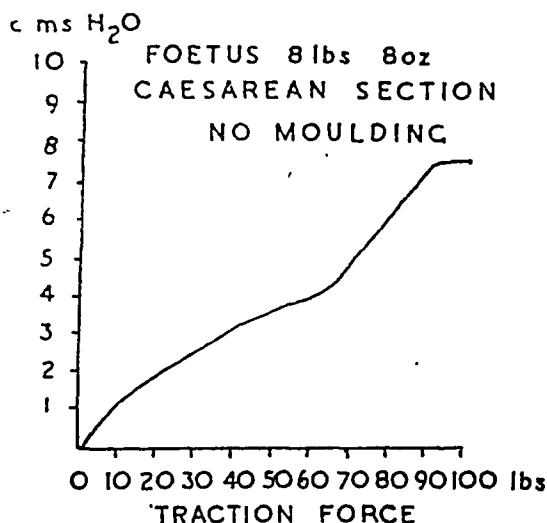


FIG. 3

In all other cases the results are probably influenced by some degree of moulding but they are no less valuable on that account, for in practice it is only very rarely that the forceps are applied to the unmoulded head. The skull which has been moulded by the natural forces would not be expected to withstand the same amount of compression force as the unmoulded head. This is borne out, at least in part, by the clinical evidence of a high stillbirth-rate when trial of labour is terminated by the forceps, and is substantiated by the experimental work, such as it is.

When the head is not unduly moulded the rise is slow up to 50 pounds, more rapid from 50 pounds to 70 pounds with little or no rise thereafter. This type of rising intra-

cranial pressure is shown graphically (Fig. 4), and was found in 3 cases.

In 2 other cases without marked moulding the rise of pressure was fairly constant until between 70 pounds and 80 pounds when a further rise could not be obtained (Fig. 5).

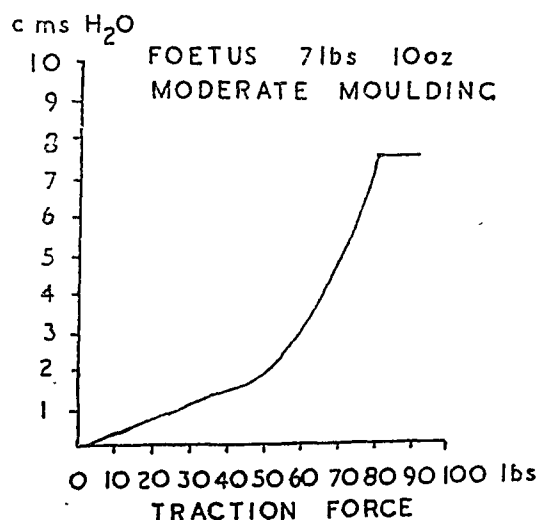


FIG. 4

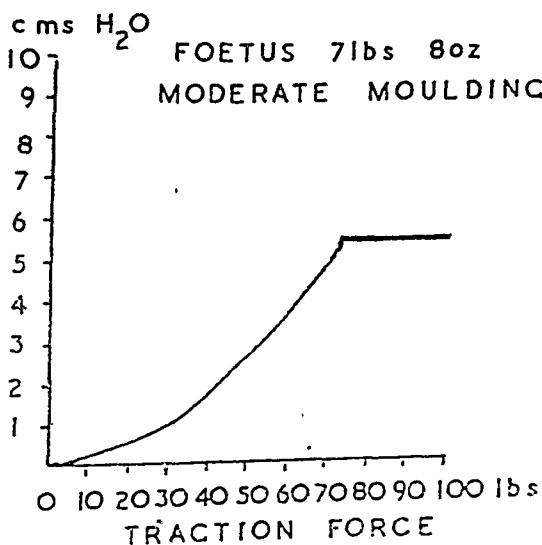


FIG. 5

NOTE—Figs. 3, 4 and 5, graphic representations of rising intracranial pressure in relation to traction force. (See context.)

In 1 case with extreme moulding the manometer became stationary when traction force was only 40 pounds.

In 2 or 3 cases a result could not be got. Sometimes it was difficult to obtain cerebrospinal fluid, but if it were reasonably certain that the needle had entered the canal the introduction of a few c.cm. of water seemed to re-establish the necessary continuity with the cerebral system. On 2 occasions blood-tinged cerebrospinal fluid was forced along the tube into the manometer.

Attempts to introduce the needle into the cisterna magna were not very successful. Owing to the position of the head, the needle fouls the improvised resistance. If introduced into a lateral ventricle the needle is fouled by the traction rods.

It was early noticed that the water level does not rise *pari passu* with the traction force and that when a force is exerted and maintained the water continues to rise and only after some time is a stationary level reached. There may be one of two causes operating here. In the first place the continued rise of the water level may be due to the fact that the cerebrospinal fluid is escaping from a wider into a narrower canal. In the second place it may be due to the fact that the resistance of the skull is slowly overcome, and that while any particular compression force will produce a certain degree of moulding, this degree is only reached after the force has been applied for some time.

The interpretation of results was not easy and the number of experiments too few to allow any generalization. They do little more than confirm what most experienced operators believe already. When traction is made on the forceps intracranial pressure begins to rise very early and fairly regularly up to a traction force of 50 pounds. From 50 pounds up to 70 pounds the rise of this pressure is more rapid. A force of

70 pounds appears to be, in the foetus weighing from 7 pounds to 8 pounds, a critical level of traction since in most cases it has been impossible to obtain any rise in intracranial pressure when the force has been raised beyond this. The water level remains stationary even when the force has been raised to 100 pounds and the inference is drawn that traction round about 70 pounds compresses the cranial contents to the extent of interfering with the movement of cerebrospinal fluid from the cerebral system to the spinal canal. The earlier signs of severe compression in the extremely moulded head and their delayed appearance in the unmoulded head are exactly what would be expected.

The fact remains, however, that it has not been possible to demonstrate experimentally the validity of the original theory that intracranial tension only begins to rise when compression force has broken through the resistance and moulding of the skull. Intracranial tension begins to rise as soon as traction force is applied, but how far the early rise is significant is not clear. The normal intracranial tension in the adult is only about 10 cm. of water, yet the total rise through the whole range of traction from 10 pounds to 100 pounds in the still-born foetal head rarely reaches this level.

These experimental results are put forward tentatively. Suitable material has rarely been available to the writer, and some of the earlier experiments were ruined by the difficulty of fixing the head against powerful traction. How far the validity of experimental work is affected by absence of the vitality of living structures, post-mortem changes, loss of normal intracranial tension and many other factors must at present remain largely unknown. Had the results obtained been entirely negative or should further work show some different interpretation, there is still good reason to measure traction force. The greater safety

provided for the foetus and maternal tissues by the "cushion" effect of the spring has already been referred to, but, with experience, by correlating the traction force with the other factors effecting delivery, there comes a more exact knowledge of what can be safely done and what can be done only with some danger. The problem of head compression is a big one, but there is no reason to believe that its solution is utterly impossible.

THE PRACTICAL PROBLEM.

In practice it has been found that the great majority of forceps deliveries can be completed with a force no greater than 50 pounds and if descent of the head does not begin when this traction force has been reached it may be for one of the following reasons:

- (1) There is malposition of the head.
- (2) There is extension of the head.
- (3) There is disproportion between head and pelvis.
- (4) There is other obstruction.
- (5) There is malposition of the forceps.
- (6) There is a large foetus.
- (7) The forceps have been applied too early.

Faced with the necessity of using a traction force greater than 50 pounds it becomes incumbent upon the operator to remove the blades and to review the mechanics of the problem which he has set out to solve. The solution does not often lie in the application of more force. In the majority of cases a more expert technique is required and in a minority of cases another method of delivery is indicated. When the traction force has reached about 70 pounds the limit of safety has been reached in the average case.

There may or may not be much variation in the capacity of individual foetuses of the

same weight to withstand head compression—material has not been available to work this out—but as we have no method of gauging this capacity it is obvious that if traction force is to be always safe it must be kept at the lower limits. Weight usually runs parallel with maturity, but when the maturity is the same the heavier foetus would seem to withstand relatively greater compression of the head. Some effect of sub-lethal compression of brain tissue is reflected in the difficulty of getting babies, delivered by the forceps, to feed. During the early days of life such infants tend towards pallor or slight cyanosis, are listless, and apparently the excitability of the sucking reflex is reduced. It is notable that these effects are more frequently seen when the traction force has been high relative to the weight. In general the capacity of the foetal head to withstand compression is directly proportionate to the weight of the foetus, but there is no doubt that the severity of maternal laceration is also in direct proportion to the traction force. In primigravidae especially the danger of severe laceration increases progressively as the indicator moves upwards beyond the 50 pounds mark.

The above statements are applicable irrespective of the depth to which the head has descended into the pelvis—whether it be above the brim or on the pelvic floor.

It is instructive to compare the *vis a tergo* with the *vis a fronte*—the natural powers of expulsion with the unnatural force of extraction. The following passage is from DeLee: "The power of the uterine contraction cannot be accurately measured. Schatz, with his tokodynamometer, a rubber bag half filled with water, lying in the uterus, connected with a manometer, found that the uterine contractions during the first stage showed a pressure of from 7 to 10 pounds, and during the 2nd stage, when the force of the abdominal muscles

was added, it was about trebled. Woodbury, Hamilton, and Torpin, with the optical manometer, found the uterine pressure on the foetal head to be 4 to 8 Kg. (8.8-17.6 pounds) and the abdominal muscles increase these expulsive forces to 12 to 21 Kg. (26.4-46.2 pounds). Clinically, the power of the uterine contraction may often be appreciated. It may crush the baby's head or fracture its bones. The physician's hand in the uterus may be squeezed so hard that it becomes insensible and paralysed, but only in pathologic cases. In rare cases tumultuous action of the uterus and abdominal muscles may eject the infant from the vulva with much force. Probably the ordinary amount of force exerted by the uterus and abdomen rarely exceeds 30 pounds."

Reference to the literature quoted by DeLee shows that the force referred to is a total force. The traction force is also a total force, and not only is it usually very much in excess of the natural forces, but it is applied to the head as a direct pull, whereas the natural forces are applied to the trunk and buttocks and reach the head as an indirect push. There are 3 main factors whereby the natural forces expel the foetus in normal labour: they propel the head into the position of greatest mechanical advantage, they adapt the shape of the head by moulding to increase this advantage, and they produce distension of the soft parts by effecting a slow and intermittent descent of the head. Traction force is often applied with the head unfavourably placed and extraction is completed in minutes as compared with the hours taken by the expulsive forces in most primigravidae. The soft parts are disrupted rather than distended by traction force. It would seem, therefore, that the forceps operation in all its details is frequently a complete reversal of the physiological process of expulsion, and it may be asked, need it be so? It is

usually possible to bring the head into a favourable position or to apply the blades in such a manner that traction will bring the head into this position. The one factor which lends itself to complete control is the traction force, and yet this is the very one which is most apt to get out of hand. What is the need for haste? If the indication for forceps delivery is foetal distress, rapid extraction by powerful traction may only precipitate the very event which the operation was designed to avoid. If the indication is maternal distress, haemorrhage and shock together with the prolonged anaesthesia necessary to effect repair, may only add to the gravity of the mother's condition. Moreover, unless lacerations are completely repaired—and sometimes despite this—there is always puerperal sepsis, and the aftermath of gynaecological troubles to be reckoned with at a later date.

What is to be done if the head does not come down with a pull up to 50 pounds and the requirements for safe forceps delivery satisfied? The natural forces may be simulated so far as possible, the force raised slowly to 50 pounds, maintained there for a brief period, and then lowered. After 2 minutes the same pull is repeated, and in this way a rhythmical traction force developed. If it is considered that more force is necessary then traction force can be raised by 5 pounds at a time and the same rhythmic repetition exercised with each increment. When the pull reaches 70 pounds the foetus may be in danger of losing its life and severe laceration of the mother, if she be a primigravida, is almost inevitable, for whatever doubt there may be as to the capacity of the foetal head to withstand compression—and it must be admitted that it is considerable—there can be no doubt that as the force is raised above 50 pounds the danger of laceration rises with it. In the case of a multipara with a history of 1

or more spontaneous deliveries of full-time infants, failure of the head to descend with a pull up to 50 pounds always suggests that there is some serious obstruction to descent.

It has been found that sometimes, when the force required to effect delivery with the patient in the lithotomy position has seemed to be excessive, the removal of the blades and the resort to the operation in the left lateral position has allowed delivery by a smaller force. The reason for this is not quite clear but the following case is of interest.

The patient was a young primigravida and the foetus estimated to be about 8 pounds. The head had been on the pelvic floor for nearly 2 hours before forceps delivery was attempted and no difficulty was anticipated. It was soon realized, however, that delivery was to be difficult. With the patient in the lithotomy position the traction force was gradually raised to 95 pounds—a force which experience has suggested to be the absolute maximum even when the foetus is a large one. Failing to effect delivery at this level of traction the blades were removed and reapplied with the patient in the left lateral position when delivery was accomplished with a maximal pull of 80 pounds. In the 1st application the blades had been placed over the ears with the occiput directly anterior and examination of the infant showed that the tip of each blade had reached to the angle of the jaw. The 2nd application of the blades had also been over the ears but it was found that the tips of the blades lay further forward, well over the cheeks with the long axis of each blade lying more accurately in the mentovertical diameter. It would seem that the application of the forceps with the patient in the lithotomy position allows the weight of the shafts and handles as they hang free over the perineum to tilt the blades so that when they are locked they grip the head with their long axis lying across the mentovertical diameter, and the direction of traction then lies too far back. This tilting of the blades is also produced by the tendency to press back the handles against the perineum when locking. The more accurate application of the blades in the left lateral position can

be easily demonstrated and may account for the greater ease of forceps delivery sometimes observed. In the above case the infant weighed 8 pounds 4 ounces, and cried lustily immediately it was born, but despite a deep episiotomy there was severe vaginal laceration (Figs. 7 and 8).

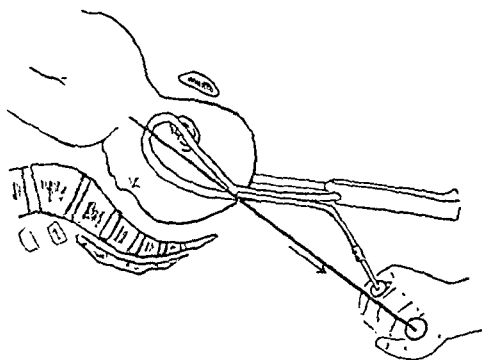


FIG. 7.

Forceps applied in lithotomy position. Tendency is to depress the handles when locking so that long axis of the blades lies obliquely across the mentovertical diameter. Direction of traction then lies too far back.

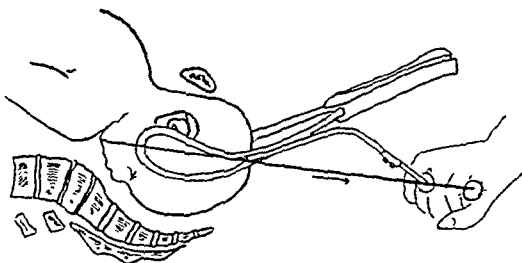


FIG. 8.

The forceps applied in left lateral position. Blades have been accurately placed along the mentovertical diameter. Direction of traction is in the axis of the birth canal.

It is often difficult to estimate the size of the foetus and to correlate it to pelvic capacity. Whether or not traction should be continued beyond 70 pounds will depend on the judgment of the operator. It must be emphasized that the measurement of traction force is not a substitute for judgment and experience, but is merely an adjunct thereto, helping to render judgment more accurate and to narrow down the interpretation of experience to something

more definite than such terms as "stiff" or "difficult" so frequently applied to the forceps operation.

SUMMARY.

1. A method of controlling axis-traction is described.

2. Evidence has been brought forward to suggest that the foetal brain can withstand only a small amount of compression force.

3. When the foetus is of average weight, the head fully flexed, the long diameter lying anteroposteriorly and the forceps accurately applied to the sides of the head, experimental work suggests that dangerous compression force develops with a traction force of about 70 pounds and may be much less if the head is already well moulded by the natural forces.

4. In practice most operations are completed with a force no greater than 50 pounds. The need for greater force suggests the presence of some abnormality.

5. A method of forceps extraction is suggested.

I am indebted to Professor R. W. Johnstone for advice and criticism, also to Dr. John Miller, who designed Instrument No. 2. I wish also to thank Mr. T. C. Riddell, Mr. Spence and the Staff of Messrs. John Hastie and Co. Ltd., for their generous help in the construction of the traction handles. This paper is published with the permission of Dr. Johnstone, Medical Officer of Health, Greenock.

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Correlation of Physical and Emotional Phenomena of Natural Labour

BY

GRANTLY DICK READ, M.D.

THE monograph is presented in reply to requests from doctors and midwives for further information about natural or physiological childbirth. This demand was precipitated by the Report of the Royal College of Obstetricians and Gynaecologists, published just over a year ago, in which references were made to "the excellent results obtained by those who aimed at physiological labour."

The standard textbooks of obstetrics have not yet included this teaching. I have chosen the "Correlation of Physical and Emotional Phenomena of Labour" because I consider it the most important of many aspects of this subject that are worthy of explication. It is not generally recognized that in childbirth there is an "emotional labour" which is as definite and important as its physical counterpart. This must be understood if parturition is to be conducted as a physiological performance.

This investigation has extended over a period of 15-20 years, and observations have been made upon 600-700 cases which I have attended personally, and other records of cases in which the mothers have been conscious at the birth of their children. Anaesthesia, and little or no analgesia, was used in the 2nd stage of labour, although the women were offered it and knew it to be immediately available should they have discomfort which they considered to be unbearable or unjustifiable.

It has been possible, therefore, to observe the phenomena of natural childbirth in the

light of modern science, for the act of reproducing a specie is unnatural:

- (a) If it is an unbearably painful or alarming experience, and
- (b) If drugs or anaesthetics have masked the significance of either physical or emotional events.

ORIGIN OF THIS RESEARCH.

From certain experiences among the mothers of Whitechapel, Bethnal Green, and later in the rural districts of France and Belgium, and in parts of Asia, I was persuaded that the attitude of a woman towards her confinement had a considerable influence upon the manner in which she bore her child. I had to find an answer to the question—"Is labour easy because a woman is calm, or is she calm because her labour is easy?" and conversely—"Is a woman pained and frightened because her labour is difficult, or is her labour difficult and painful because she is frightened?" From a scrutiny of cases, with these thoughts in my mind, the early hypothesis took shape that—"Fear is in some way the chief pain-producing agent in otherwise normal labour."

In a long series of methodical observations and, so far as possible, controls, this proved to be correct, and is to-day widely accepted as an established theory. The results of its practical application in eliminating pain from natural labour have been favourable, not only in my own practice but in the work of others who have adopted this teaching.

THE PAIN-FEAR-TENSION SYNDROME OF LABOUR.

Pain is the mental interpretation of harmful stimulus, and fear the intensifier of stimulus-interpretation. The biological purpose of each is protective. The physiological reaction to each is tension.

"A stimulus of fixed magnitude applied to any specific sensory receptor produces a motor response commensurate with the intensity of its interpretation."

In labour, fear produces tension in circular fibres of the uterus by stimulating the sympathetic nerve supply. Tension in these fibres opposes the action of the longitudinal muscle fibres supplied by the pelvic autonomic. Increased tension in the lower uterine segment and cervix causes pain, and pain intensifies fear, and so on, until the exhausting agony of a relatively obstructed labour supervenes!

The motor response to sensory stimuli makes or mars the neuro-muscular harmony of the mechanism. The efferent response is in relation to the intensity of the afferent message, and the polarity of the uterus is sustained by the integrity of afferent impulses and the veracity of their interpretation.

This Pain-Fear-Tension syndrome of labour may be controlled or avoided by correct interpretation of stimulus. The syndrome is most vulnerable to attack at the "point of fear." The causes and conditions of fear in childbirth are numerous. The antidote of fear is confidence, and the establishment of complete faith in the mind of a woman is the most effective method of minimizing pain.

I do not wish to disagree with the advocates of applied anaesthesia, whether it is caudal, inhalation or parenteral, for pain must be prevented or relieved. Every effort to make childbirth a painless function should be carefully considered.

I prefer rather to emphasize emotional influences, and my investigations enable me to postulate as a basis for argument that if fear is eliminated very few physiological labours are so distressing that women will demand relief from pain. If fear predominates a woman should demand anaesthesia in order to escape from pain, for without relief she will most surely suffer.

If the emotional processes of childbirth are understood, they can be preserved, directed and controlled, so that the "threshold of pain" remains constant and the interpretation of sensations faithful.

The phenomena of labour should be taught during late pregnancy and recalled as they present themselves in labour. But the phenomena of labour must be understood in order to be taught. Unless an attendant knows the general trend of the emotional states of a woman in labour, he cannot recognize variations, either within or without the normal. Instruction and the establishment of complete confidence before labour commences is necessary. Physical exercises and relaxation are adjuvants to the fixation of faith as well as to physical performance, for such antenatal classes arouse enthusiasm and interest in childbirth and often afford opportunities for personal relation with the teacher who may and should be with the woman during labour.

A woman who is physically perfect but emotionally uncontrolled will have more difficulty and discomfort than a controlled and confident patient who is without special physical preparation, and who appears to be inadequately equipped for the strain upon her.

Three important precepts should be kept in the mind when considering childbirth as a natural phenomenon:

The first is a maxim of fundamental importance. Physiological labour exhibits certain emotional states which may vary

within normal limits. It must be recognized that if and when emotional manifestations are abnormal, parturition becomes pathological and requires treatment by scientific means as expeditiously as an obstructed labour. It is a serious complication, and one of the major causes of maternal morbidity.

The second is the apothegm that "when a child is born there are 3 labours:

- (a) of the mother, physical;
- (b) of the mother, emotional;
- (c) of the attendant."

The last is frequently distressing! But any one of these 3 components of the event may decide or derange the normality of childbirth.

The third is an axiom: "The art of

physiological childbirth is the art of control." This also has 3 specific implications:

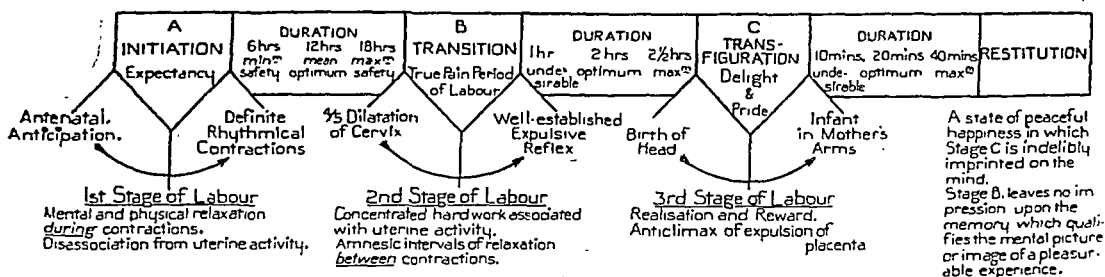
- (a) The woman's control of herself.
- (b) The obstetrician's control of the woman.
- (c) The obstetrician's self-control.

These 3 are largely interdependent, but should (c) fail under the provocation of evil anticipation, the course of natural childbirth will immediately be disrupted.

We must therefore apply ourselves to understand the forces of the mind and their influence upon childbirth, and the variations within normal which may occur without inhibition of the mechanism or creation of painful sensations.

For this purpose I have prepared a chart

CORRELATION OF PHYSICAL AND EMOTIONAL PHENOMENA OF NATURAL LABOUR



A1. Commencement
Exilaration and animation.

2. Uterine Cervix dilates
1/5-2/5
Realisation of helplessness, but cheerful.

3. Uterine Cervix dilates
2/5-3/5
Serious demeanour—uneasiness of mind—desire for understanding and companionship.

4. Uterine Cervix dilates
3/5-4/5
Strengthening contractions invite conflict—confidence v. fear—relaxation v. tension.

B5. Uterine Cervix dilates
4/5—full
Test of faith. Acute sensitiveness—horror of loneliness—demand for kindly but firm sympathy and assistance. Beginning of "True Pain period" of Labour. Demand for relief of unbearable pain justified. Control difficult.

Relaxation during contractions becomes impossible owing to early expulsive efforts occurring.

B6. Expulsive Reflex
Revival of personality and confidence.

7. With Rotation of Head
Onset of amnesia between contractions.

8. Head Mid-cavity
Fundamental primitive self appears. Discretion and discrimination 'low' (variable).

9. Head reaches Pelvic Floor
Impatience and frustration. Careless and willing to remain untidy.

10. Stretching and Thinning of Perineum
Determination and perseverance. Exasperation threatens confidence.

11. Before Crowning
Feeling of mental and physical exhaustion.

12. Stretching of Vulva and Crowning
Discretion and discrimination very weak. Discomfort and anxiety again threaten control.

C13. Birth of Head
Complete awareness. Amnesic state ceases. Mental alertness.

C14. Birth Complete
Entirely concerned with baby. No thought for herself.

C15. Sound of First Cry
Incredulity. All weariness vanishes.

C16. Warmth of Child on her Limbs
Reality.

C17. Sight of Infant
Fascinated wonder. Enchantment.

C18. Her Infant in Her Arms
State of emotional ecstasy which varies both in manifestation and control.

19. Strong and Prolonged Contraction of Uterus.
Reflex and painless stimulus to sympathetic nervous system.

20. Removal of Infant to Cot.
Period of rumination and rest.

21. Rhythmic Contractions
Anticlimax requiring tact—full treatment. Some return of amnesic state may be noted.

22. Placenta in Vagina.

23. Effort of Complete Expulsion
Satisfying sense of accomplishment. Demand for refreshment and her baby to be brought near.

showing the general trend of emotional changes during labour and their relation to the physical progress of parturition.

Such a chart can only show a "general trend," for there is no absolute in human reaction to given circumstance. Variations and degrees of manifestation are as numerable as the experiences, predispositions and associations from which mental processes arise. Such emotional changes as I have recorded are indeed significant for relatively constant occurrence and the absence of gross divergence from the mean.

It is not expected that this purely medical aspect of parturition will appeal to the surgical mind, but in practice it so alters the picture of childbirth that any doubt of the correctness of its theoretical basis is dispelled. By bearing in mind the significance of the pain-fear-tension syndrome, painless natural childbirth can be achieved, and it is upon such cases that these observations upon normal emotional reactions during labour have been made.

(A) *Stage of initiation.*

When a woman has been properly prepared so that her mind and body are in a healthy, fearless condition, there is almost invariably a phase during the last 2 to 3 weeks of pregnancy when she becomes anxious for the birth of her child. It is partly boredom at the limitations which the distended uterus places upon her activities, but an element of impatience and excitement is also present. If this is carefully fostered and she is taught how to recognize the onset of labour, the early signs of the beginning of the 1st stage are heralded with animation and exhilaration. She is delighted that at last her child is coming, and the long months of pregnancy finished. It is of the utmost importance to maintain that sense of fearless expectancy.

The sequence of events from elation is determination, calm, relaxation, conscious

control and neuromuscular harmony, with almost complete inhibition of sympathetic nervous system influences. Conversely, if this spirit is suppressed, it may initiate fear and apprehension. Such fear promotes a desire to escape, mental turmoil, protective tension, loss of control, and a disturbed neuromuscular harmony.

If a woman starts labour in a confident, happy and expectant frame of mind, the insidious enemies of control can be repelled by those who are trained to recognize the earliest signs of their intrusion.

As the cervix dilates and the uterine contractions become stronger, the woman becomes quieter. She realizes her helplessness, but remains cheerful. From 2/5th to 3/5th dilatation of the cervix, her animation gives place to a more serious demeanour. If she is practised in the art of physical relaxation during the contractions she does not complain of pain, but a certain uneasiness of mind may be detected. She desires companionship, understanding and sympathetic encouragement. It is extremely important that this phase of labour should be well cared for, for a woman who becomes alarmed is liable to physical discomforts which will make it impossible for the labour to develop its natural course.

When the cervix is 3/5th dilated, the strengthening contractions not only invite conflict in her mind but are frequently coincident with physical tiredness. It is at this time in a 1st stage lasting 10 to 15 hours that an attendant must consider the induction of sleep. According to the type of woman, the experienced observer will be guided in his use of sedatives. It is not for pain that soporifics are advised, for frequently the complaint is not of pain, but of weariness. An hour or 2 of peaceful mental and physical relaxation at this stage is invaluable, not only for the maintenance of control, but also to counteract the real

test which she is likely to undergo between 4/5th and full dilation of the cervix.

(B) *Stage of Transition.*

The conduct of this phase, which I term the transition, is the key to the success of the whole process. When labour is painful it is at this time that women are so frequently allowed to suffer. Physically, they are acutely sensitive, and there is little doubt that abnormal tension of the cervix and even laceration occur in some women however well they have conducted themselves up to this point.

The appearance and behaviour of a woman during this transition from 1st to 2nd stage is so typical that once observed it will not subsequently be mistaken. It is now that the physician should be present, and it is now that the skilled midwife will send for him. A woman needs kindly and firm sympathy; the induction of confidence is often of greater assistance to her than the early induction of anaesthesia. She must be told that this phase is short-lived, that the pain in her back will not increase but will diminish when the expulsive reflex is established. Her sacral region should be rubbed and her courage fortified by the realization of personal care and attention.

With full dilatation her breathing will become interrupted from time to time by a "catch" in the throat which is the initiation of the closure of her air-way. She will expect the irresistible urge to bear down, and although 5 or 6 contractions may occur with this reflex imperfectly established, soon, with adequate instruction, she will hold her breath and gently bear down. From this point the pain in the back (in the absence of any old injury of the back) will disappear. Her sensitiveness decreases, she relaxes between the contractions and wakes to use each expulsive effort with a will. As the head descends, the onset of a

dulling of her consciousness between contractions may be observed. I have described this previously as an amnesic state, but recent observations have made me aware of the similarity of the behaviour of a woman in the 2nd stage to that of a man in a state of so-called anoxia. The cause of this mental state, however, is controversial, and a satisfactory explanation has not yet been given for its occurrence.

With the progress of this stage, discretion and discrimination are obviously affected. She will become impatient, careless of her appearance and manner. Remarks are made which are not only incongruous but quite atypical of the woman herself. Such remarks are often either forgotten entirely or only recalled as a fantasy.

When the presenting part reaches the pelvic floor, and when both the woman and her attendant may be called upon to exhibit considerable patience, a feeling of mental and physical exhaustion combined with exasperation at the apparent ineffectiveness of her efforts, will call for encouragement, explanation and confidence.

As she becomes conscious of the stretching of the vulva, the threat of increased discomfort may alarm her. Every woman at this stage should know that anaesthesia or at least analgesia is within her grasp. The urge to escape is more frequently the result of fear than of pain. The sense of impending pain is not infrequently present, but if enquiry is made, many women will explain that it is not what they feel but the fear that the next contraction will be painful that is alarming.

She should, of course, have been warned of the rupturing of the membranes, and the downward thrust and retreat of the head before crowning must be explained. These things frighten or disappoint women if they do not understand them.

(C) *Phase of Transfiguration.*

With the birth of the head there is gratifying relief. If the woman has collaborated, it is possible to prevent injury to the perineum in all but exceptionally inelastic vulvae. With the birth of the shoulders, which usually coincides with the first cry of the baby, she completely recovers her awareness. The amnesic state disappears, and she is alert. It is my custom to rotate the shoulders on delivery so that she may look down and see her baby. She likes to hold or "shake" her baby's hand. There is no thought of discomfort; she usually urges me to deliver the body so that the sex of the child may be known. It is a picture of complete happiness. The questions asked are stereotyped. She is incredulous, and frequently says it is almost impossible to believe. Her physical appearance, mentality and behaviour are completely changed. She becomes, in her happiness, a transfigured woman. She should be handed her baby as soon as the cord is divided.

The influence of this condition of physiological emotional ecstasy upon the uterus is immediate contraction. The 3rd stage of the parturition of a happy mother is rarely longer than 20 minutes, and maternal loss of blood practically negligible. I have noticed that the placentae of girls bearing illegitimate babies are not infrequently retained. This may or may not be the result of some breakdown in the normal emotional influences upon the uterine mechanism.

The actual expulsion of the placenta is a miniature 2nd stage. Not infrequently there is a return of the amnesic state when the uterus contracts firmly, and again a tremendous sense of effort followed by relief when it is all over.

Throughout labour, the correlation of the physical and emotional phenomena is so consistent that the dependence of one upon the other cannot be overlooked. To be

guided only by the mechanical and physical progress of the function is to know but half the story. If the emotional phenomena are neither observed nor understood they are best excluded by hypnotics and anaesthetics. For if they are uncontrolled and allowed to become abnormal, not only is the physical progress of labour impeded, but the woman is caused to suffer. Such suffering is unjustifiable, and must be prevented.

This series of cases has demonstrated that suffering in physiological childbirth can be prevented by understanding and maintaining the controlled rectitude of the emotions, not for their elimination but for their perfecting influence upon the physical phenomena of a physiological function.

Certain benefits result from the knowledge and control of the emotional phenomena of labour.

(1) Fear can be eliminated, and thereby pain-causing factors excluded.

(2) The natural amnesia of the 2nd stage in a controlled woman produces the equivalent of complete anoci-association without the employment of narcotics or anaesthetics. It must be remembered that anoci-association not only excludes fear and pain but also shock and postpartum neurosis. Inhalation anaesthesia hides pain and fear in the cloak of unconsciousness, but does not prevent postpartum shock or the sequelae of nervous and emotional impairment.

(3) Interference is less frequently necessary in a conscious, controlled patient in labour.

In a recent series of normal cases it was observed that low forceps were used in under 3 per cent, episiotomies under 7 per cent, lacerations of perineum or vaginal mucosa needing repair under 10 per cent.

Retained placenta and postpartum haemorrhage (20 ounces or more) rare. Postpartum shock (severe) 2 cases in over 150

associated with excessive haemorrhage and not with nervous exhaustion.

(4) The desirable stage of transformation—which is obliterated by anaesthesia—increases uterine contractions and expedites placental separation and expulsion with little or no maternal loss. The subsequent reproductory life of many women has been influenced by this experience. They want more children, and cannot understand the “never-again” woman. The importance of this result is inestimable.

(5) The uninjured birth canal, with appropriate exercises, rapidly regains its tone. Subinvolution is uncommon. The majority of women, after a natural parturition, find desire more pronounced and coition mutually more satisfactory. Obstetricians must not overlook the domestic and social importance of this relation. To produce a child and impair a woman's ability to be a good marital partner all too frequently ruins a home. Forceps, episiotomies and inadequately repaired perineums have more than obstetric implications.

(6) From natural labours we can learn the significance of the physiological phenomena of parturition. With fuller understanding pain and fear will be eliminated from childbirth. Women will again be willing to have more children and once more build up society upon the solid foundation of family life. From natural childbirth we may discern the solutions of many problems which may well revolutionize our attitude towards and our conduct of labour.

For instance, what is the disposition and nature of the fuel of excitation in the early

1st stage which is consumed in hilarity until muscular activity of strengthening uterine contractions employs it?

Emotional tone is diminished by kinetic reaction, and as the muscle work increases the demeanour of the woman changes.

We must enquire, why should this be so? Has it any relation to the establishment of expulsive contractions, and if so can we retain the balance between fuel and metabolites in order to avoid inertia or excessive violence and the dangers they present?

Shall we not be able to learn more of human reactions to forces beyond human control by the study of labour? Many chemical, electrical and psychological phenomena associated with labour may be investigated, but only in conscious women whose emotional balance is not subjected to fear or pain.

The mysteries of childbirth and the problems of reproduction will not be solved by innovations and interventions. The secrets of this fundamental process of life will gradually dawn upon us as we patiently and humbly strive to discover the genius of God.

Books by the author in which more details of this subject may be found.

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London: Churchill, 1935. Chapter V. “The Influence of the Emotions upon Pregnancy and Parturition.”

Intrauterine Foetal Death Due to Rhesus Incompatibility Its Diagnosis and Management.

BY

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A RELATIVELY common and well-known incident in the practice of obstetrics is the death of the foetus *in utero* during the course of pregnancy. In the majority of instances such death can be explained as being due, for example, to asphyxia, following accidental haemorrhage, placenta praevia, obstructed labour, chronic nephritis and the like, or to foetal abnormalities incompatible with extrauterine existence.

During recent years it has become generally recognized that intrauterine death may occur as a manifestation of haemolytic disease of the newborn or erythroblastosis foetalis, with the delivery of a child with generalized oedema (hydrops foetalis), or with maceration (the 4th variation of the disease as described by Javert,¹ Henderson,² Harrison and Meacock³).

The iso-immunization theory expounded by Levine, Burnham, Katzin and Vogel⁴ in 1941, explains the aetiological connexion between the Rhesus factor and haemolytic disease of the newborn.

The object of this paper is to present data collected from the literature, which may simplify the diagnosis of intrauterine foetal death due to Rhesus incompatibility, and assist in the management of such cases during and after pregnancy, thereby lessening the hazards of incompatible blood transfusions and their attendant dangers.

DIAGNOSIS.

(1) *Previous Obstetrical History.*

A detailed history of previous pregnan-

cies is an important aid in the diagnosis, especially in multiparae who have had 1 or more infants developing jaundice or pallor soon after birth, which children have died without or recovered with a transfusion. One or more unexplained stillbirths, premature labours or neonatal deaths should, in every case, be suspected as being due to haemolytic disease until disproved. It is apparent that the Rhesus factor is responsible in the production of late but not early abortions, according to Schwartz and Levine.⁵ (See Cases 1 and 2 described below).

It is a fact that almost all such women bear 1 or more unaffected children, before giving birth to an infant with erythroblastosis, and practically all infants born subsequently are affected with the disease. This fact should not detract, however, from a full maternal serological investigation, particularly in the presence of a history of previous blood transfusion, in primiparae who are delivered of stillborn children.

The following cases illustrate histories suggestive of haemolytic disease of the newborn with intrauterine foetal death.

CASE 1. 7-para; aged 36 years; 6½ months pregnant. Admitted to hospital in 1944 complaining of cessation of foetal movements, which had been present since the 20th week of pregnancy.

Previous obstetrical history. (1) stillbirth, ? cause; (2) living and healthy; (3) died after 16 days with marked jaundice; (4) living and healthy; (5) stillbirth, macerated; (6) died with marked jaundice.

Examination. Size of uterus equivalent to 36 weeks pregnancy. Foetal parts felt with some difficulty. Foetal heart sounds not heard. Blood-pressure and urine normal. Wassermann reaction negative.

Twenty-four hours after admission normal delivery occurred. The infant was stillborn, grossly oedematous, and with signs of early maceration. The placenta was markedly enlarged for the duration of the pregnancy, oedematous, and was more than one-sixth the child's weight (Plate I).

CASE 2. 5-para; aged 34 years; 34 weeks pregnant. Admitted to hospital in 1944 complaining of cessation of foetal movements, a feeling of "heaviness in the lower abdomen," and brownish vaginal discharge.

Previous obstetrical history. 1st marriage.

(1) 1937, premature twins, both died, ? cause; (2) 1938, living and healthy; (3) 1939, living and healthy.

2nd marriage. (4) 1942, died after 24 hours with marked jaundice.

Examination. Uterus over-enlarged for the duration of the amenorrhoea; equivalent to pregnancy at term. Foetal parts not felt. Foetal heart sounds not heard. Brown vaginal discharge, slightly offensive. Blood-pressure and urine normal. Wassermann reaction negative. Normal delivery occurred spontaneously 2 days after admission, following medical induction of labour. The infant was macerated; the placenta pale, unhealthy looking and oedematous, weighed considerably more than one-sixth of the foetus (Plate II).

CASE 3. (Case 1 readmitted in 1945). 8-para; 5 months pregnant, complaining of "not having felt movements." Foetal parts were easily palpable, but the foetal heart sounds were not heard. The height of the fundus of the uterus corresponded with a 32 weeks' pregnancy. X-ray examination revealed a typical frog-like or Buddha-like attitude of the foetus, with a halo around the foetal head. (Javert's sign.)

Spontaneous delivery occurred after artificial rupture of the membranes. The foetus was grossly macerated, and the placenta excessively enlarged for a 5 months' pregnancy (Plate III).

(2) *Abdominal Examination.*

In the majority of cases with hydrops, uterine enlargement is out of all proportion to the duration of the amenorrhoea, due to the combined weight of the foetus and excessively enlarged placenta, and not due to hydramnios (Javert¹). According to Henderson,² in the 4th variation of erythroblastosis foetalis characterized by foetal maceration, hydramnios is common. Difficulty in palpating the foetus is probably due to either excessive liquor or anterior attachment of the large oedematous placenta.

(3) *Serological Investigation.*

(a) *Rhesus testing.* It is now generally accepted that the introduction of Rh antigen into an individual in whom it is not normally present, may result in the production of anti-Rh agglutinins. If anti-Rh agglutinins are produced a subsequent pregnancy may terminate unfavourably because the agglutinins transferred to the foetus may cause erythroblastosis, or subsequent introduction of large amounts of blood containing antigen may result in undesirable or even fatal reaction. According to Levine⁶ the immunization produced by the Rh factor probably persists for life, serious haemolytic reactions such as oliguria, jaundice and convulsions occurring as long as 22 years after the birth of a jaundiced child. Wiener, Silverman and Aronson⁷ report a case of haemolytic reaction 11 years after the birth of the last of 5 Rh positive infants, and Mollison⁸ a case of 16 years interval from the birth of the last child. Butler, Danforth and Scudder⁹ report a series of 25 cases with transfusion incompatibility, as manifested by oliguria in 25 cases, jaundice in 10, and convulsions in 8.

Young and Kariher¹⁰ maintain that serious haemolytic reaction may follow transfusion without causing chills, fever or other dramatic symptoms and signs.

Introduction of Rh agglutinins may be accomplished either by the passage through the placental barrier of Rh positive cells from the foetal circulation or by transfusion with Rh positive blood, resulting in immunization of the mother, followed by fatal haemolytic disease of the newborn in the form of foetal hydrops.

The following case illustrates an example of incompatible blood transfusion due to the Rh factor, resulting in foetal hydrops and severe maternal complications.

CASE 4. 2-para; aged 30 years; 36 weeks pregnant. Admitted to hospital because of extreme shortness of breath, palpitation and oedema of the lower extremities, due apparently to anaemia.

Previous obstetrical history. 1940, living and healthy child. No previous abortions.

Examination. The patient was very pale and short of breath; there was oedema of the lower extremities and sacrum. Blood-pressure and urine were normal. Abnormality not found in heart or lungs. Wassermann reaction negative.

Abdomen. Uterus corresponded with the period of amenorrhoea. Vertex presentation, left occipito anterior; foetal heart sounds heard.

In view of the anaemia (haemoglobin 35 per cent) and the nearness of the pregnancy to term, it was decided to give a blood transfusion. One pint of grouped compatible blood was administered slowly. After about 200 c.cm. had been given, severe reaction occurred with a temperature of 101°F., rapid pulse-rate and severe backache. The drip was immediately discontinued.

The foetal heart sounds were not heard soon afterwards, and foetal movements ceased. Labour commenced spontaneously 8 hours later, a still-born child, with generalized oedema and a pale-pink oedematous placenta, being delivered (Plate IV).

Severe oliguria, with accompanying jaundice supervened in the next 48 hours, only 2 ounces of bile-stained urine being voided. A sodium sulphate intravenous drip transfusion produced rapid diuresis. Blood transfusion with Rh negative blood 3 days later was tolerated without reaction confirming our suspicion of Rhesus incompatibility, after

finding a high titre of anti-Rh agglutinins in the maternal serum.

The finding in the mother's blood of typical agglutinins (usually anti-Rh) can be accepted as almost conclusive evidence of affection. On the other hand, failure to find agglutinins, say 20 days after delivery, does not exclude the diagnosis (Stratton and Langley¹¹). The mere demonstration that the mother is Rh negative and the infant (or father) Rh positive, can be considered no more than suggestive of affection, in event of failure to find anti-Rh agglutinins in the mother's serum.

The finding of antibody during pregnancy does not prove that the foetus will necessarily suffer from erythroblastosis, firstly because the foetus may be Rh negative (if the father is heterozygous) and therefore not affected, and secondly because on rare occasions it has been shown that an Rh negative mother with Rh antibody during the puerperium may have an Rh positive baby which does not show signs of the disease (Boorman, Dodd and Molli-son¹²).

In a series of 24 cases of unexplained intrauterine foetal death well in advance of labour, as evidenced by foetal maceration, Schwartz and Levine⁵ found that the incidence of erythroblastosis was somewhere between 16.6 and 29.1 per cent.

In the 4 cases described above, all were Rh negative and revealed a high titre of anti-Rh agglutinins in the maternal serum, thus confirming the diagnosis of intrauterine foetal death due to Rhesus incompatibility.

(b) *Wassermann reaction.* The possibility of excessive infarction of the placenta due to syphilis, with intrauterine foetal death and the birth of a macerated infant, is generally accepted as one of the commonest causes of late abortion. A routine Wassermann reaction during the antenatal



PLATE I.

HAEMOLYTIC DISEASE OF THE NEWBORN.

(26 weeks pregnancy. Hydrops with slight maceration)

L.R.



PLATE II.
HAEMOLYTIC DISEASE OF THE NEWBORN.
(Macerated type. 34 weeks pregnancy)

L.R.



PLATE III.
HAEMOLYTIC DISEASE OF THE NEWBORN.
(20 weeks pregnancy Extreme maceration)

L.R.



PLATE IV.
HAEMOLYTIC DISEASE OF THE NEWBORN (HYDROPS).
(Following incompatible blood transfusion)

L.R.

period or in the puerperium will usually establish the diagnosis, although a concomitant Rh incompatibility cannot be excluded. The absence of areas of haemopoiesis will however preclude the diagnosis of erythroblastosis.

(4) *X-ray Examination.*

The Buddha-like habitus or frog-like attitude of the foetus *in utero*, due to foetal ascites and enlargement of the liver, is described by Javert¹ as an important diagnostic feature of foetal hydrops, which is further characterized by the presence of a halo around the foetal head due to oedema of the scalp. Overlapping of the foetal skull is a well-known sign of maceration and foetal death.

(5) *Autopsy Findings.*

(a) *Foetus.* In cases of hydrops, the foetus is usually grossly oedematous, the skin easily macerated by the slightest touch. The liver and spleen which are usually enlarged, show some degree of degeneration, pigment deposits and haemopoiesis. Davidsohn¹³ describes local haemopoiesis in other organs, including the kidneys and suprarenals. In cases of maceration, described by Henderson, Javert, Harrison and Meacock as a 4th variation of haemolytic disease of the newborn, the foetus shows little or no oedema, marked maceration, and diffuse hepatic cirrhosis and splenomegaly. This type of disease bears a superficial resemblance to congenital syphilis, but close examination of the foetus and placenta renders differentiation easy.

(b) *Placenta.* In almost every instance this organ is oedematous and pale pink in colour. The normal weight-ratio of placenta to foetus of 1:6, is decreased. Davidsohn¹³ found ratios of 1:1.3, and 1:1.37. The characteristic microscopic changes are fibrosis, oedema and haemopoiesis.

The gross appearance of the foetus and the placenta is in itself not sufficient to establish a diagnosis of erythroblastosis foetalis. Potter¹⁴ believes that certain histological evidence must be present and that all hydropic conditions of stillborn infants should not be accepted as being due to haemolytic disease. She believes that foetal hydrops is not a disease entity, but only a sign common to several different morbid conditions. The possible existence of erythroblastosis was considered in over 100 infants subjected to postmortem examination. Diagnosis of erythroblastosis was established in over 50: in the remainder the condition was believed not to exist. Among those in whom erythroblastosis was absent, 17 had severe oedema characteristically described as foetal hydrops. These infants comprised an entity entirely separate from haemolytic disease. In contrast to erythroblastosis, the spleen and liver were never enlarged and the spleen was often hypoplastic. The maternal histories of these cases showed many differences from those usually found in association with erythroblastosis. Six were primigravidae, a condition which did not occur in erythroblastosis, except for 1 patient who had had numerous previous transfusions. Follow-up of 11 of the 17 mothers revealed that 6 had given birth to 7 normal children, and there were not any subsequent unfruitful pregnancies. This was in contrast to the erythroblastosis group, in which 15 mothers had subsequent pregnancies, 15 of which resulted in the birth of infants with haemolytic disease.

Differential diagnosis. Other conditions producing intrauterine foetal death before term are syphilis, chronic nephritis, essential hypertension, diabetes mellitus, ? excessive calcification of the placenta, abnormal carbohydrate metabolism and other unknown causes.

MANAGEMENT OF INTRAUTERINE FOETAL DEATH DUE TO RHESUS INCOMPATIBILITY.

The main aim would be to obtain a normal delivery, prevent complications in the 3rd stage of labour, particularly postpartum haemorrhage, and prepare for the immediate and energetic treatment of excessive bleeding should it occur. Javert¹ reported an increase in the incidence of postpartum haemorrhage among the hydropic group in the study of 47 cases of erythroblastosis. In the 4 cases reported above, complications in the 3rd stage of labour were conspicuous by their absence. The necessity for Rh negative blood must be stressed, and therefore a suitable donor should be made available, should a blood transfusion be required.

Once the diagnosis has been settled labour can be induced. Stimulation of labour by an oestrin-induction is often successful. Where this procedure fails, routine medical induction will usually succeed. Artificial rupture of the membranes should be performed only as a last resort to bring on labour, because of the increased danger of infection.

In the absence of suitable blood, in cases of emergency, it has been suggested that it would be wiser to administer plasma, until Rh negative blood be made available. It would indeed be a catastrophe if a patient's life were jeopardized or lost, because of incompatible blood (the recent suggestion¹⁵ that all pregnant women be tested for the Rh factor before confinement is wholeheartedly supported).

Finally, before the patient is discharged from hospital, it would be wise to instruct her about her "blood condition" and warn her against confinement "at home."

QUESTION OF FURTHER PREGNANCIES.

The remote chances of further successful pregnancies and the dangers of incom-

patible blood transfusion, would point against further attempts at conception. The unreliability of contraceptive measures in preventing further pregnancies, may make it advisable to perform surgical sterilization by resection of the Fallopian tubes.

SUMMARY AND CONCLUSIONS.

1. The diagnosis and management of intrauterine foetal death due to Rhesus incompatibility is discussed.

2. The suggestion of routine Rhesus investigation in all pregnant women is supported, in order to avoid transfusion reactions.

3. The avoidance of further pregnancies, following several unsuccessful pregnancies due to Rhesus incompatibility, is advisable.

My grateful thanks to Dr. F. Stratton, Regional Transfusion Officer, Manchester, for his help in the serological tests for the Rh factor, and his deeply appreciated advice. To Dr. Lois Stent and Dr. G. Crawford I am indebted for their help in the investigation of the cases recorded above, also to Sister Winters who took the clinical photographs. Finally I wish to thank Mr. G. Brown, Medical Superintendent, for his permission to record the cases.

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A Case of Intestinal Obstruction Associated with Complete Procidentia

BY

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ON October 1st, 1945, a woman of 62 was brought by ambulance to the gynaecological clinic. She had been sent for advice about the treatment of her procidentia. The patient had not allowed her private doctor to make a full examination of her condition.

History. Her only complaint was that the womb had been coming down for the previous 10 months, and was now causing discomfort and making it difficult for her to get about. She had had 2 children, the 2nd being born 26 years ago. Deliveries were normal. The menopause occurred at the age of 48, and there had not been any bleeding since. She admitted occasional difficulty with micturition and said that perhaps there had been some recent increase in its frequency. There had not been incontinence. She had not sought treatment for the prolapse and had mentioned it to her doctor only 2 days previously. When asked why she had come to hospital by ambulance, she said that for the last 5 days she had been confined to bed with a "bilious attack" and had not been able to keep down any food or drink. Her bowels, however, had been opened daily without any difficulty until 2 days before admission. She had not had abdominal pain.

On Examination. The patient looked ill; the skin was dry and there was evidence of

recent loss of weight. Her tongue was clean and moist. The pulse-rate was 88 and of good volume. The abdomen showed slight general distension and a reducible umbilical hernia. There was no visible peristalsis. Palpation did not reveal any definite evidence of tumour, although there was some fullness in the left iliac fossa. There was shifting dullness in the flanks, and bowel sounds were increased.

At the vulva a complete procidentia could be seen. The cervix was eroded and covered with foul discharge. From a round opening, 1 inch across, in the posterior fornix, about 2 inches from the external os, there extruded a coil of small intestine, some 18 inches long, with its mesentery. It was markedly discoloured and, on the antimesenteric border of the middle of the loop, there was a gangrenous area 3 to 4 inches across. On the left side of the intestine there was another gangrenous organ which was supposed at the time to be the appendix. The prolapsed viscera were covered with drying lymph and had an offensive odour. The site of herniation did not form a tight ring and was not closed by adhesions. Gentle palpation with a finger through this orifice revealed the fundus of an atrophic uterus immediately in front and at the level of the vulva. The legs were grossly oedematous.



Showing resected bowel with a ring pessary placed to indicate the site of the operation in the posterior fornix.
D. & C.

The diagnosis was made of intestinal obstruction due to herniation of ileum through a perforation in the prolapsed pouch of Douglas, and the patient was admitted at once to a surgical ward for laparotomy.

Further examination showed a temperature of 100.2°F., pulse-rate 108, respirations 24, and a blood-pressure of 170/110. Heart and lungs were normal.

Operation (by E. N. C.) Anaesthesia was induced with Pentothal and continued with nitrous oxide, oxygen and ether.

Through a right lower paramedian incision it was found that the last 2 or 3 feet of ileum had been dragged down into the pelvis, with 18 inches of it actually prolapsed through an aperture in the everted pouch of Douglas. The ileum proximal to this was distended and the caecum was dragged down to the pelvic brim, the appendix being in its normal relation to it. The ileum was resected at the level of the pelvic brim and a side-to-side anastomosis performed between the proximal loop of ileum and the transverse colon. A caecostomy was made through an oblique incision over the right iliac fossa, to safeguard the anastomosis.

The patient was then placed in the lithotomy position and the resected loop of bowel withdrawn from the hole in the posterior fornix. The structure which had been taken for the appendix was found to be the left Fallopian tube, and this was ligated at its base and removed. After a drainage tube had been inserted, the opening in the posterior fornix was firmly packed with flavine gauze to prevent further prolapse of abdominal contents.

The accompanying plate shows the resected bowel, with a ring pessary placed to indicate the site of the aperture in the posterior fornix.

Subsequent progress. At the end of

operation the patient seemed to be in fairly good condition, but in spite of transfusion and other measures, her condition deteriorated and she died some 24 hours later. An autopsy was not obtained.

DISCUSSION.

It would have been remarkable if this elderly patient had survived a severe operation, bearing some resemblance to an abdominoperineal excision of the rectum, after having been completely obstructed for 2 days.

Excision from below was contemplated, but was rejected because of the inflamed and offensive condition of the everted vagina and cervix. A clean anastomosis would have been extremely difficult to obtain and faecal fistula a very probable result. The immediate postoperative shock would possibly have been less, but a severe cellulitis might have resulted from any enlargement of the hole in the posterior fornix which would have been necessary to bring down sufficient bowel to resect through healthy tissue. The problem of preventing a further prolapse of bowel would have been a grave one, as repair of the infected posterior vaginal wall would have been extremely difficult.

The question arises as to the cause of the perforation. There was not any history of trauma to the prolapsed vaginal wall, nor of the use of a cup and stem pessary. There may have been an injury which the patient never mentioned. The only other presumption is that the complete procidentia had been an old standing one and that constant rubbing, probably associated with lack of cleanliness, had been responsible for ulceration with eventual complete breakdown of posterior vaginal wall and underlying tissue and peritoneum. If the perforation was spontaneous, we believe this case of extrusion of a loop of bowel through the pouch of Douglas to be unique.

Improved Design for a Combined Textbook of Obstetrics and Gynaecology*

BY

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In his Bradshaw Lecture published in 1931, the late John S. Fairbairn¹ wrote: "Etymologically the term gynaecology should cover both midwifery and the diseases of women, but the title that should belong to the whole has been usurped by a part, largely owing to a separation in practice between the two which occurred during the developmental stages of gynaecology. This drift-apart arose from maternity cases being excluded from the general and segregated in special hospitals in pre-Listerian days, and from advances in gynaecology being so far along purely surgical lines that a type of surgeon-gynaecologist arose, and time was when a real divorce between the two divisions of the subject might have taken place. But recent developments have been in the opposite direction, and a greater realization of the essential unity of midwifery and the diseases of women has been a characteristic feature of recent thought."

The concept of the essential unity of obstetrics and gynaecology has found concrete expression in the combined textbook, but the result has usually been disappointing because the author or editor concerned has failed to present the combined subject simply and in logical sequence and has merely produced one or more omnibus volumes containing a mass of information

about both obstetrics and gynaecology. This is regrettable because there can be little doubt that the student would have a more balanced outlook on obstetrics and gynaecology if he were brought up, as it were, on a combined textbook.

The purpose of this communication is to suggest that the avowed object of the combined textbook, namely the integration of obstetrics and gynaecology, can be simply and successfully achieved by arranging the subject matter in the following manner:

SECTION ONE.

Anatomy and Physiology of the Genital Organs.

Anatomy.

Development.

Physiology (brief mention of the function of individual organs).

SECTION TWO.

Anatomy and Physiology of the Female Reproductive Function.

The female sex cycle.

Reproductive endocrinology.

Pregnancy.

Labour.

Puerperium.

Newly born child.

Menopausal climacteric.

SECTION THREE.

Management of the Normal Reproductive Function.

Methods of examination.

Puberty and menstruation.

Sexual intercourse.

The maternity services.

Diagnosis of pregnancy.

* Read at the North of England Obstetrical and Gynaecological Society, Manchester, October 19th, 1945.

Antenatal care.
Labour.
Puerperium and postnatal care.
Newly born child.
Menopausal climacteric.

SECTION FOUR.

Pathology of the Genital Organs.

Investigation of a case.
Principal symptoms.
Malformations.
Mechanical lesions (lacerations, displacements, atresia and stenosis).
Inflammation.
Hypertrophy (including subinvolution) and heterotopia (cervical erosion, endometriosis).
Benign tumours.
Malignant tumours.
Retrogressive lesions.
Gynaecological operations.
Other gynaecological procedures.

SECTION FIVE.

Pathology of the Reproductive Function.

Disorders of the female sex cycle.
Disorders of the sexual function.
Sterility.
Anomalies of implantation of the ovum (ectopic, cornual, angular and cervical pregnancy, placenta praevia).
Abnormalities and diseases of the decidua and ovum.
General diseases associated with pregnancy.
Local diseases associated with pregnancy.
General diseases resulting from pregnancy.
Local diseases resulting from pregnancy.

Abortion and premature labour.
Dystocia (faults in the powers).
Dystocia (faults in the foetus, etc.).
Dystocia (faults in the passages).
Obstructed labour.
Injuries and displacements resulting from labour.
Haemorrhage and shock.
Puerperal complications.
Abnormalities and diseases of the newly born child.
Obstetrical operations.
Maternal, foetal and neonatal mortality and morbidity.
Disorders of the menopausal climacteric.

APPENDIX.

Alimentary and urinary tracts in relation to obstetrics and gynaecology.
Medico-legal problems.
Radiodiagnosis and radiotherapy.
Etc., etc.

It will be observed that normal structure and function are described first, then abnormal structure, comprising the "organic" part of gynaecology, and, finally, abnormal function including "dysfunctional" gynaecology. This arrangement makes it possible for all parts or phases of the reproductive function in health and disease to be dealt with in proper sequence.

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The Premature Baby

BY

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BECAUSE of the declining population and the low birth-rate, more attention is being given to the prevention of early loss of life, of which the greatest cause is prematurity.

During the last few years the causes of premature birth have been more thoroughly investigated; in addition, more studies have been made of the causes of mortality in the premature infant and the influence of pregnancy, labour and social status on this mortality.

Definition of prematurity.

The definition recommended by the International Committee at Geneva in 1937 is now generally accepted and any infant weighing 5½ pounds or less at birth is considered a premature baby regardless of the period of gestation.

Importance of prematurity.

If all premature births could be eliminated, the stillbirth-rate could be almost halved^{1, 2} and the neonatal death-rate more than halved.^{1, 2, 3}

Although the incidence of premature birth in the City of Birmingham during 1944 was only 6.3 per cent, yet 44.2 per cent of the stillbirths and 57.3 per cent of the neonatal deaths occurred in association with these premature births.

The United States Bureau of the Census give prematurity as a single cause of death in 47 per cent of neonatal deaths, while

Beck³ in 1941 reported that 60 per cent of the neonatal deaths occurred in premature babies.

Causes of prematurity.

The common known causes of premature birth are maternal ill-health, multiple pregnancy and foetal deformity but the cause is unknown in a large number of cases.

Maternal ill-health.

Maternal ill-health was reported in 32.5 per cent of premature births by Baird⁴ and in 47.9 per cent by Crosse.² Toxaemia of pregnancy is the greatest cause of maternal ill-health and occurred in 16.1 per cent and 29.3 per cent respectively of the 2 series of premature births just mentioned. Baird⁴ has shown that the association of toxæmia with prematurity is twice as common in the poor as in the well-to-do.

Multiple pregnancy.

This complication was reported as occurring in 12.2 per cent of premature births by Baird⁴ and 16.6 per cent by Crosse.²

Foetal deformity.

Foetal deformity occurred in association with 3.4 per cent of Baird's⁴ cases and 5.9 per cent of Crosse's² cases.

Unknown causes.

No known cause could be found for the

onset of premature labour in 32.7 per cent of cases by Sandifer,⁵ in 37.7 per cent cases by Crosse² and in 51.9 per cent of cases by Baird.⁴ More attention is now being given to the effect of social conditions on prematurity, and Baird has recently reported that the incidence of prematurity in Aberdeen is almost twice as high in the Registrar-General's social classes III, IV and V, as in classes I and II. In the former classes over 50 per cent of the prematurity is unexplained, while in the latter very few come within this category.

Experiments, such as those of the People's League of Health,⁶ Ebbs, Tisdall and Scott⁷ and Utheim-Toverüd⁸ have shown that the incidence of prematurity can be reduced by ensuring an adequate diet during pregnancy.

Causes of neonatal mortality in the premature baby.

Recent investigations by Wilcox,⁹ Diddle and Plass,¹⁰ McNeil¹¹ and Crosse² have shown that the principal causes of death are prematurity only (including atelectasis), intracranial birth injury, infections and foetal deformity.

Prematurity only.

This cause has been found in percentages varying from 50 per cent¹⁰ to 64 per cent² of the deaths in the investigations already mentioned.

This cause of death has been reduced each year since 1938 in the City of Birmingham. During 1938-1941, when the neonatal mortality of premature babies was 40.2 per cent, 62 per cent of these deaths were due to prematurity only, compared with 44 per cent during 1944, when the neonatal deaths of premature babies had been reduced to 24.3 per cent.

Birth injury.

Intracranial birth injury has accounted

for percentages varying from 12.4 per cent² to 21.3 per cent⁹ of the deaths.^{2, 9, 10, 11} In Birmingham the percentage has risen from 9 per cent to 16 per cent during the period 1938 to 1944 but owing to the fall in the premature neonatal death-rate there is no great increase in the number of deaths due to this cause.

Infections.

Infections have accounted for percentages varying from 11.4 per cent² to 23.1 per cent¹¹ of the deaths.^{2, 9, 10, 11} This cause has accounted for approximately 8 per cent of the deaths in Birmingham each year since 1938, but owing to the decrease in the premature neonatal death-rate this indicates a decrease in the total number of deaths due to this cause.

Foetal deformity.

This complication has been associated with 1.1 per cent⁹ to 13 per cent¹⁰ of the deaths in the investigations mentioned.^{2, 9, 10, 11} During the years 1938 to 1944 in Birmingham, the percentage of deaths associated with foetal deformity has almost doubled (8 per cent of deaths in 1944), but this increase is more apparent than real, because the premature neonatal mortality has been reduced by two-fifths during this time.

INFLUENCE OF PREGNANCY, LABOUR AND SOCIAL STATUS ON THE MORTALITY OF THE PREMATURE INFANT.

Influence of pregnancy.

McNeil¹¹ has given figures showing that abnormality of pregnancy doubles the combined foetal and neonatal mortality of premature infants.

Bundesen¹² considered inadequate antenatal care a large factor in the cause of death in the premature baby. He found complications of pregnancy in 26.5 per cent

deaths of premature babies under 2 weeks, as compared with 10.9 per cent of full-time infant deaths under the same age.

Influence of labour.

According to McNeil¹¹ complications of labour increase the combined foetal and neonatal mortality of premature infants by about one-fifth.

Operative procedures.

Other things being equal, the lowest mortality-rates are found after a spontaneous vertex delivery and the mortality rises with breech delivery, mid and high forceps extraction and Caesarean section.^{3, 10, 12, 13}

Bundesen¹² showed that skilled operative procedures were beneficial when employed for complications of labour, but that they involved great risk of neonatal death when there were no definite indications for interference. It was pointed out that unnecessary interference was particularly hazardous when complications of pregnancy were present.

Caesarean section. High mortality-rates for premature babies delivered by this method have been given by Ingram,¹³ Beck,³ Diddle and Plass,¹⁰ and these workers consider that Caesarean section, in the absence of serious maternal conditions, is not a child-saving procedure.

Clifford¹⁴ pointed out that while Caesarean section eliminated the factor of trauma during delivery, it substituted the one of asphyxia.

Bundesen¹² gave high mortality-rates from asphyxia in infants delivered by Caesarean section, and recommended avoidance of this mode of delivery unless very definite indications were present.

Breech delivery carries a high mortality-rate from intracranial birth injury owing to the compressibility of the premature head, the fragility of the intracranial blood

vessels, and the relatively low concentration of prothrombin in the blood. Asphyxia due to aspiration is also likely to occur.

Multiple pregnancy has a definite influence on the neonatal mortality. Beck³ stated that the additional risks of multiple pregnancy more than offset the increased degree of maturity which the multiple-born infant enjoys over the single-born infant of the same weight. This was also demonstrated by Crosse² (24.3 per cent of multiple-born infants dying before the age of 4 weeks, compared with 9 per cent of single-born infants dying within the same period).

Use of oxytocics. Rapid delivery leads to a high foetal and neonatal mortality.^{3, 10}

Bundesen¹² has suggested that posterior pituitary extract should be administered with extreme caution during labour, and only when the indications have been determined as proper by an obstetrician.

Anaesthetics and analgesics. The respiratory centre of the premature baby is poorly developed and easily depressed, therefore anaesthetics and analgesics should be used with great care. According to Bundesen¹² "Physicians should bear in mind the threat to the life of the infant produced by the injudicious use of analgesics, and not permit the mother's demands for painless childbirth to overweigh their good judgment to the degree that they employ drugs to alleviate pain at risk to the infant's life." Lund¹⁵ regards the misuse of anaesthetics as one of the more important causes of asphyxia, and the Royal College of Obstetricians and Gynaecologists¹⁶ has drawn attention to the widespread use of anaesthetics and analgesics by unskilled administrators which has resulted in neonatal deaths and stillbirths.

Influence of social conditions.

According to Baird,⁴ not only is the incidence of prematurity greater in the

lower social classes, but the proportion of babies with the smaller birth weights is also greater in these classes. This leads to a greater mortality-rate due to the fact that the mortality increases as the birth weight decreases. Baird also found that the mortality in each weight group was greater in the lower than in the upper social classes; in other words premature babies born to poor mothers had a poor vitality.

RESULTS OF INVESTIGATIONS.

As a result of these investigations it has become apparent that the mortality due to prematurity will be reduced only by

1. Improved social conditions.
2. More thorough antenatal care for all expectant mothers.
3. More specialized care during premature labours.
4. More specialized care for premature infants after delivery.

Improvement of social conditions.

More efforts must be made with regard to improving housing, wages, diet and opportunity for rest during pregnancy, and if the best results are to be obtained, these improvements must be combined with better health education.

A long-term policy to improve the social status of the lower classes is to be preferred, but during the interim period much can be done during pregnancy, by attention to rest and diet. The importance of "first class" proteins, vitamins and mineral salts should be stressed.

Antenatal care.

Generally speaking, the chances of survival of the child increase with the period of gestation up to term, so that every effort should be made to carry on each pregnancy to as near term as possible. In the presence of maternal ill-health this can only be done if a sufficient number of antenatal beds are

provided for the treatment of the conditions likely to lead to premature labour.

Early diagnosis of complications.

The early diagnosis of conditions later to lead to premature labour is of importance, and every pregnant woman should be medically examined at certain stages. The Royal College of Obstetricians and Gynaecologists¹⁶ has suggested that "midwives should not be regarded as competent to undertake unaided the antenatal care of the expectant mother, but should always work in collaboration with the general practitioner or the obstetrician of the clinic." According to Galdston¹⁷ the desirable medical attendant is one "adequately trained and experienced in obstetrics, and so aware of his limitations that, when emergencies arise which are beyond his competence he will not delay in securing help." The Royal College of Obstetricians and Gynaecologists¹⁶ has stressed the importance of special experience for doctors wishing to take part in their suggested National Maternity Service.

Induction of premature labour.

Induction of premature labour should only be considered in the presence of very definite indications, always remembering that the earlier labour is induced the smaller is the chance of survival for the child. Induction of labour in certain conditions deserve mention:

Toxaemia of pregnancy. Induction presents special difficulties in this condition, because the child may die of prematurity if labour is induced too early, but it may die *in utero* if delivery is delayed; in addition the needs of the mother have to be considered. Expert advice should be sought if induction is considered before the 35th week of pregnancy.

Cardiac conditions. As the mortality of the infant is high before the 35th week,

labour should not be induced before this unless special indications are present. If, however, congestive failure develops, the infant mortality rises considerably.¹⁸ Therefore, if there is any fear of this complication arising, induction of premature labour is indicated for the sake of the child as well as for the mother.

Antepartum haemorrhage. When pregnancy is complicated by slight vaginal haemorrhage, it may be possible to delay diagnostic examination until the child has a reasonable chance of survival. Beck³ recommends hospitalization and large doses of progesterone, in the hope of arresting the haemorrhage and prolonging the pregnancy. The risks to the mother must, of course, be weighed if placenta praevia is suspected. In the case of central placenta praevia when a considerable loss of blood has occurred, more frequent and larger blood transfusions are recommended before Caesarean section is performed in order to reduce the mortality of the infant.³

Multiple pregnancy.

Rest combined with the use of progesterone and vitamin E may help to prolong the pregnancy and thus improve the chances of survival of the infants.¹²

Provision of antenatal beds.

Good antenatal care must be supported by a sufficient number of antenatal beds. The Royal College of Obstetricians and Gynaecologists¹⁶ has suggested that the number provided should not be less than one-third of the lying-in beds. This would seem to be an adequate number if hospital accommodation is provided for 70 per cent of all deliveries, as suggested by the College. If, however, less accommodation is available, a larger proportion of antenatal beds will be required in order to deal with the antenatal complications of cases booked for delivery in their own homes.

CARE DURING DELIVERY.

The chief dangers for a premature baby during labour are intracranial birth injury and asphyxia.

As the result of the studies of Ingram,¹³ Bundesen,¹² Beck,³ and Diddle and Plass¹⁰ on the influence of labour on the mortality of the premature infant, the following points have emerged with regard to the conduct of a premature labour:

1. A spontaneous vertex delivery should be obtained if possible.
2. Interference should be avoided unless definite indications are present; this is very important if complications of pregnancy have occurred.
3. Breech deliveries should be avoided if possible.
4. Caesarean section should be performed only when definite indications are present. Ideally, it should be performed under a local or spinal anaesthetic and sedatives should not be used prior to operation.
5. Sedatives and anaesthetics which depress the respiratory centre are contra-indicated in a normal premature labour.
6. Posterior pituitary extract and other oxytocics should be used only in exceptional circumstances.
7. The use of vitamin K is recommended.

CARE OF THE INFANT IN THE LABOUR ROOM.

The possible dangers immediately after delivery are loss of body heat, infection and difficulty in establishing respiration.

Preservation of body heat and prevention of infection must start from the moment of birth. Loss of heat is reduced by keeping the room warm (80°F.), wrapping the child in a towel and blanket as soon as it is born, and transferring it to a warm cot after the umbilical cord has been divided.

To prevent infection, labour must be conducted with all the usual aseptic precautions. Even greater precautions than usual should be taken to exclude persons suffering from infection, and to ensure that all attendants wear gowns and masks, and wash their hands before handling the child. The child should be received into a sterile or clean towel.

If there are respiratory difficulties, there is some difference of opinion as to the best position in which to place the child. Provided the airway is clear, breathing is made easier by raising the head, but if much fluid is present, the head should be lowered while clearing the air passages. If intracranial trauma is suspected, the head should not be kept low any longer than necessary. The older mechanical forms of artificial respiration have been replaced by modern insufflation methods. Oxygen or 7 per cent CO₂ in oxygen may be used, but pure CO₂ should be avoided.

Windle has shown the advantages of not tying the umbilical cord until it has ceased to pulsate, and this procedure is advised if the condition of the child warrants the necessary delay.

Indication for hospital care.

If the infant has been born at home, it is necessary to decide whether it can be nursed at home or whether it should be removed to hospital. If the home is unsuitable, the infant should be moved, and even if the home facilities are excellent, removal should be urged if respiratory or feeding difficulties are likely. Infants with these difficulties require a 24-hour nursing service, and except in the case of quadruplets or quintets, the only economic method of obtaining this service is in hospital.

When it is decided to transfer a baby to hospital, this should be done at once; before infection, chilling, or feeding difficulties have occurred. The infant should not be

bathed, dressed or fed before removal, but left undisturbed in a warm cot until called for.

Transport.

Arrangements must be made to keep the baby warm during transit. Some authorities use electric incubators,^{21, 22} while others use baskets heated with hot water bottles.² The former are more suitable for long journeys, but the latter give excellent results for shorter journeys.

Babies should be accompanied by a trained nurse or midwife, and facilities should be available for clearing the air passage (a mucus catheter) and administration of oxygen.

Suitable arrangements must be made for cleaning and refitting baskets and incubators between cases.

HOSPITAL CARE.

According to the Ministry of Health Circular²³ sent to all welfare authorities in England, the following provision should be made:

1. Warm wards.
2. Cool wards.
3. Isolation wards.
4. Accommodation for nursing mothers.
5. Kitchen.
6. Milk room.

Crosse² has stressed the importance of providing demonstration rooms in which mothers can be taught how to look after their babies before taking them home. Such rooms can also be used for mothers coming from their homes to feed their babies.

If institutional treatment were to be provided for every premature baby, approximately 5 to 6 cots would be required per 1,000 live births assuming that 5 or 6 per cent of the live births are premature

and that 1 cot can accommodate 10 infants per year. However, hospital care should be necessary for only a small proportion of infants over $4\frac{1}{2}$ pounds, and a more practical suggestion would be the provision of 2 to 4 cots per 1,000 live births; a minimum of 2 in areas with good housing conditions, but 4 in areas where housing is poor.

The Ministry of Health recommends 10 premature cots for every 100 maternity beds. This figure would not appear to be adequate unless maternity beds were provided for at least 50 per cent of the births in the area.

Siting of units for premature babies.

These units have been set up in both maternity and children's hospitals. On the whole, an attachment to a maternity hospital seems to be preferable, on the following grounds.

1. Infants born in the Maternity Hospital do not have to be moved far.
2. Breast milk is more readily available.
3. The mother can continue under the care of the midwife and obstetrician.
4. There is less risk of infection.

Medical staff.

Although the position of the paediatrician in the ordinary nurseries of a maternity hospital is still controversial, it is generally recognized that he should be in charge of units for premature babies. This paediatrician should visit the ward at regular intervals, conducting ward rounds and discussing current problems, and be available at other times for consultation. He should be responsible for the plan of care, which should be available in writing for the use of both medical and nursing staff. In addition, there should be a medical officer on call, day and night, who will visit the wards daily, examine infants on admission and before discharge, and answer emergency calls.

Nursing staff.

The Ministry of Health Circular²² recommends a highly skilled nursing staff on a numerical basis of 1 nurse to $1\frac{1}{2}$ infants, and suggests that a unit of 20 cots requires 6 permanent senior nurses who have had special training with premature infants.

Crosse² has indicated the importance of having sufficient senior nurses trained in the care of premature babies to ensure at least 1 of these senior nurses being on duty at all hours of the day and night (allowing for sickness and other relief). In this way only, can the pupils be adequately supervised and continuity of care be obtained.

Economic size of unit.

In order to comply with the recommendations of the Rushcliffe Committee a minimum of 4 nurses is required to ensure constant staffing of any unit however small. These 4 nurses can staff a unit of 6 cots, but will all have to be trained in the care of the premature baby. A unit of 12 cots can be staffed with 4 specially trained nurses and 4 pupils. A unit of under 6 cots is, therefore, not to be recommended. With every cot over 6 (and up to about 14) the cost of staffing is reduced because pupils can be used as additional staff.

Size of wards.

Fifty square feet of floor space should be provided for each cot and the maximal number of cots in an open ward (not cubicled) should be 4 to 6; 4 in the wards for the smaller infants, and 6 in those for the larger infants, these being the maximal numbers of each type that 1 nurse can care for satisfactorily.² If possible the cots of the larger and older babies (those having a cough reflex, and a strong cry and therefore more likely to spread infection by droplet) should be separated by partitions. If the smaller infants are put into cubicles, the difficulty of constant observation is a dis-

advantage to be weighed against the rather remote possibility of droplet infection.

HOME CARE.

Recommendations in the Ministry of Health Circular²³ are: a separate room for the mother and baby; provision of equipment on loan by the local authority; a supply of expressed breast milk when necessary; and the services of a paediatrician and a home help. Midwives and health visitors with special training and experience with premature infants are recommended as suitable persons to give attention to premature infants born at home.

The suggested equipment for loan included a cot, clothing, hot water bottles, an electric pad, a feeding-bottle, a thermometer and a mucus catheter. It is, however, doubtful whether an electric pad should be included, owing to the possibility of dangers (especially that of overheating) in unskilled hands.

The importance of the home helps in a complete maternity and infant health service was stressed by the Royal College of Obstetricians and Gynaecologists in their report on a National Maternity Service.¹⁶

Training of midwives and health visitors is of paramount importance, and the training should be carried out, if possible, in units run on single lines, with methods which can be used on the district.²

SUBSEQUENT CARE IN THE HOSPITAL NURSERY OR AT HOME.

This resolves itself into maintenance of body heat, maintenance of respiration, prevention of infection, careful feeding and early diagnosis and treatment of complications.

Maintenance of body heat.

Experience has proved that an infant thrives normally if the rectal temperature is stabilized between 96°F. and 98°F.: the small babies tend to stabilize at 96°F. and

as they gain in weight the level rises to 98°F. The dangers of attempts to raise the rectal temperature to the supposedly normal level of 99.6°F. have been shown by Blackfan,²⁴ Sisson and Clifford.²⁵ A temperature below 96°F. is injurious, leading to inanition and atelectasis.

A room temperature of 65°F. to 70°F. (humidity 65 to 70 per cent saturation), and a cot temperature of 80°F. to 95°F., both temperatures depending on the size and condition of the child, will usually maintain the body temperature at the correct level.

A closed incubator may be used if an oxygen bed is required, but excellent results can be obtained with the more simple open incubator or heated cot. Closed incubators should certainly not be considered essential. "A good nurse is worth a dozen incubators."²⁶

Clothing should cover the child completely (with the exception of the face); be of such a simple design that it can be changed without undue handling of the child, be made of non-conducting material in order to conserve body heat and be washable. Cotton is inferior to wool in preventing heat loss, therefore should not be used for permanent clothing. In emergency gangee tissue may be used as a temporary measure, but ordinary cotton-wool should be avoided, as it sticks to the body and gets into the child's mouth and nose. A suitable set of clothing for the smaller infants consists of:

1. A flannel vest, open, but overlapping in front, with tape fastenings over the shoulders.

2. A sleeveless flannel gown, open down the front with plenty of overlap and provided with a hood.

3. A soft napkin.

4. An absorbent bib.

If the infant is active, sleeves are provided, and when a weight of about 4½ pounds is reached, the hood is not required.

The provision of a bib prevents the soiling of the gown when regurgitation of food occurs.

Nursing procedures should be carried out with the minimal of exposure. Infants should be weighed in their clothes or in a blanket. Cleaning and oiling should be reduced to the minimum if the temperature is difficult to maintain.

Maintenance of respiration.

The more premature the infant the less must it be handled, if cyanotic attacks are to be avoided. The child should be placed on one or other side and never flat on its back, because of the danger of regurgitation and aspiration. The smaller infants should be fed, changed, dressed and oiled in the cot with the minimum of disturbance: any necessary handling should take place before, and not after, a feed. If oxygen is required, it may be administered by tent or funnel; the nasal catheter should be avoided because of the danger of injury to the mucus membrane and infection.

Prevention of infection.

Infection is the greatest preventible cause of death in the premature baby, and for this reason is extremely important. The danger of infection in hospital is fully recognized, but the danger in the child's own home must also be realized. In Birmingham during the first 9 months of 1945, 275 premature infants were treated at home (only 5 per cent weighed less than 4 pounds at birth) and 160 were treated in the City of Birmingham Premature Baby Unit (20 per cent less than 4 pounds at birth and 60 per cent admitted from their own homes immediately after birth). Of those treated at home 3.7 per cent are known to have died of infections before reaching the age of 4 weeks. There has not been a death from infection among the 160 cases treated in the City Unit during this period. (Since 1931 the incidence of infection in this Unit has been 1.4 per cent.)

A recent publication of the Medical Research Council²⁷ has drawn attention to the necessity for good ventilation, cot-spacing and the wearing of masks for the control of droplet-borne infection; and the treatment of floors and blankets and care during cleaning procedures for the control of dust-borne infections. Direct infection is prevented by care in handwashing, laundry and food preparation and by the elimination of communal equipment so far as possible.

The Children's Bureau (United States Department of Labor)²⁸ set out standards and recommendations for hospital care of new-born infants, full-time and premature. In this valuable publication, stress is laid on the importance of bedside care, and the necessity of avoiding communal baths and changing tables.

In the child's own home, one room must be kept for the mother and baby only; all visitors and other children being rigorously excluded.

Feeding.

In a premature baby the sucking and swallowing reflexes may be poor or even absent; there is an increased liability to regurgitation and inhalation of food; the alimentary tract is immature; and there is a greater need for fluids due to the relatively great body-water-content and the relatively poor renal function.²⁹

Underfeeding may lead to lethargy, fever, cyanosis, loss of weight, and dehydration, while overfeeding may cause gastric distension, cyanosis, diarrhoea and vomiting. The latter may lead to loss of weight and dehydration, or to inhalation and asphyxia or pneumonia.

The dangers of overfeeding are being more generally recognized. Tow³⁰ stated that "the premature infant is not a balloon to be blown up" and that "it is all too often that a zealous attendant will attempt to force

feedings; and as a result fluid will be aspirated and death ensue, either because a pneumonia develops, or because of an atelectasis that follows an obstructed bronchus." Hess and Lundeen²¹ stated that "the tendency to overfeed the young premature infant is undoubtedly one of the important factors in the mortality and morbidity found among premature babies during their first 3 to 6 weeks of life."

Stress should be laid upon survival rather than on a rapid gain in weight. Anxiety need not be felt unless the initial loss continues after the end of the 1st week, or is greater than $1\frac{1}{2}$ to 2 ounces per pound, or if the birth weight is not regained by the end of the 3rd week. Crosse² obtains the best survival-rates with the following daily quantities of fluid (feed):

3rd or 4th day, 1 ounce per pound birth weight.

7th day, 2 ounces per pound birth weight.

10th day, $2\frac{1}{2}$ ounces per pound birth weight.

14th day, 3 ounces per pound birth weight.

After the 14th day, 3 to $3\frac{1}{2}$ ounces per pound birth weight.

The premature baby requires approximately 40 to 50 calories per pound daily by the end of the 2nd week of life, and after this, 50 to 60 calories. If weak feeds are given at first and the strength is gradually increased, the calories will be automatically increased. It is a wise rule to give the lowest caloric value on which an infant will gain satisfactorily, and a small infant should not be expected to gain more than $\frac{1}{2}$ to $\frac{3}{4}$ ounce daily, if digestive upsets are to be avoided. This applies particularly to the artificially fed infant.

Breast-milk is generally accepted as being the best food for a premature infant. Some authorities prefer to increase the protein content of breast-milk by adding calcium caseinate, skimmed lactic-acid milk or casein hydrolysate, but convincing evidence of the value of this procedure has not yet been published.

If breast-milk is not available, cow's milk can be used successfully if the protein is modified, and the fat content of the feed is relatively low (1.5 to 2 per cent). Suitable feeds are therefore:

1. Sweetened condensed milk (1 in 16 to 1 in 6).

2. Unsweetened condensed milk with 1 drachm cane sugar to 3 ounces of mixture (1 in 12 to 1 in 5).

3. Full cream dried milk with 1 drachm cane sugar to 2 ounces of mixture (1 in 32 to 1 in 16).

4. Peptonised or lactified cow's milk with 1 drachm cane sugar to 2 ounces of mixture (1 in 4 to 1 in 2).

Full cream dried milk is a milk with a relatively low fat content; whereas half-cream dried milk when diluted so as to reduce the protein to a suitable level, contains too little fat for a healthy premature baby. As a general rule, "humanized" milks contain too much fat. Saline and whey should be administered only for definite indications if salt retention and oedema are to be avoided.³⁰

Feeds are given from the breast, by a bottle or Belcroy feeder, by a pipette or by catheter, according to the ability of the child to suck and to swallow. The dangers of passing the catheter through the nose (injury and infection) should be realized, and all catheter feeds given by mouth. Catheter feeding is not without danger, and should be used only by trained personnel for definite indications. It should never be used to save time or trouble.

Vitamins. The vitamin requirements are so great that extra vitamins should be given to all premature babies whether breast fed or artificially fed. The recommended dosage of vitamin D varies from 1,400 to 10,000 I.U. daily,^{31, 32, 33} but in actual practice a daily dose of 3,000 I.U. has proved sufficient. Concentrates must be used because of the deficiency in the digestion of

fat. Little is known as regards the requirements of a premature baby for the various factors of the vitamin B complex. Litchfield *et al.*,³⁴ in 1939, reported an improvement in the rate of gain in weight after the use of vitamin B concentrates. In the City of Birmingham Premature Baby Unit the administration is commenced on the 3rd day of life, and a daily dose of 0.2 mg. B₁ and B₂ with 3.0 mg. of nicotinic acid is used.

The premature infant has a special need for vitamin C in order to complete the metabolism of its protein intake and a daily dose of 50 mg. is suggested.³⁵ The administration can be commenced on the 3rd day of life. A suitable initial dose is 5 mg. of a synthetic preparation and this may be increased daily by 5 mg. until 50 mg. is being given each day. At the age of 4 weeks orange juice may be gradually substituted for part of the dose.

Mineral salts. Extra calcium and phosphorus should be given to premature babies, because of their relatively deficient stores at birth and their relatively greater growth after birth. An insufficient supply of these salts will lead to rickets even in the presence of sufficient vitamin D.³⁶ A suitable preparation is syrup of calcium lactophosphate, which can be given in a daily dose of 1 minim per pound from the end of the 2nd week of life.

No useful purpose is served if iron is administered before the age of 4 to 6 weeks,³⁷ but if commenced at this age it accelerates the expected rise in haemoglobin after the initial drop³⁸ and so prevents the development of late anaemia.

Owing to the low clearance of sodium and chlorides by the premature kidney, great care must be exercised in the use of saline.

Hormones. The use of thyroid extract first suggested by Pritchard³⁹ in 1934, has proved useful in lethargic babies with low body temperatures and atelectasis, if given in a dosage of grains 1/10 per pound daily

(in a divided dose). The administration of oestrogen has proved disappointing.^{40, 41}

COMPLICATIONS OCCURRING IN THE PREMATURE BABY.

Because of physical defects associated with prematurity certain complications occur more frequently in the premature baby than in the full-time baby, but early diagnosis and treatment improve the prognosis.

The premature baby has profited from all recent advances made in the treatment of neonatal complications; for example, transfusion with suitable blood in haemolytic disease; vitamin K and transfusion in haemorrhagic disease; sulphonamides and penicillin in infective conditions, and the more scientific administration of salt, water and glucose in cases of dehydration.

CONTINUITY OF TREATMENT.

A close contact should be maintained between the doctors and midwives in the district and the hospitals, on one hand; and the welfare authority on the other, so that the health visitor can take over the care of the infant when the midwife leaves, or when it is discharged from hospital. In some areas² the health visitor is also asked to visit the home before the child is discharged from hospital, so as to ensure suitable preparation for the reception of the child.

CO-OPERATION BETWEEN ALL PERSONS CONCERNED WITH MATERNAL AND INFANT HEALTH.

The reduction of foetal and neonatal death from prematurity can be achieved only if there is full co-operation between the obstetrician, paediatrician, general practitioner, midwife, health visitor and the various administrative officials of the local welfare authority.

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DECEMBER 1945.

Regulations for the Admission of Members.

Notice is hereby given that the Regulations for Admission of Members have been modified by increasing the amount of special and general training required in the minimum period of three years that must elapse between the candidate's obtaining a registrable medical qualification and his application for admission as a Member of the College. These modifications will apply to all candidates who sit for the Membership examination for the first time in January, 1947, or thereafter, with the proviso that candidates who have served in a medical capacity in His Majesty's Armed Forces during the present National Emergency shall have the option of applying for special permission to take the examination at any time under the provisions of the Regulations dated March 1944.

Details of the new Regulations can be obtained from the Secretary of the College.

Notice is also given that it is the intention of the College, when facilities for increased training are available, to increase the duration of the training for the Membership examination to five years. Before the necessary Regulations are introduced sufficient notice will be given to enable an intending candidate to plan his course of training.

A Meeting of the Council was held in the College House on Saturday, January 28th, 1946, with the President, Mr. Eardley Holland, in the Chair.

The following candidates were elected to the Membership of the College :

Constance Lang Beynon
Ernest William Cornwall Buckell
Walter Calvert
Raymond Gerard Cross
Sadashiv Narayan Gardé
Perla Greeves
Emilie Ellen Guthmann
Werner Paul Hirsch
William Kearney
Arthur Harold Colyear Walker
Margaret Weddell
May Davies Westerman

BOOK REVIEW

"Ophthalmia Neonatorum. The Problem after 30 Years of Statutory Notification and 60 Years of Crede-Prophylaxis." By ARNOLD SORSBY, M.D., F.R.C.S. Research Professor in Ophthalmology, Royal College of Surgeons. London: Hamish Hamilton, Ltd., 1945. 66 pages.

In this monograph there is presented an exhaustive statistical and clinical review of the subject of ophthalmia neonatorum. The author is peculiarly fitted for this task as practically all children in the County of London, suffering from ophthalmia neonatorum, are admitted to the London County Council hospital of which he is ophthalmic surgeon.

The treatise opens with a short, interesting account of the distribution of the disease throughout the world. No explanation is offered for the fact that it is not universally prevalent. Dealing with statistical data accumulated in this country since the introduction of compulsory notification, he shows the extreme variations in the incidence of the disease in different parts of the United Kingdom. This is attributable not so much to true variations in incidence, but rather to marked local differences in the criteria by which notification is made. Notification is not condemned, for its object is not the collection of statistical data, but the procuring of supervision and treatment for a child whose sight may be endangered. For a measure of the gravity of the problem, and of the efficiency of the measures taken to deal with it, figures relating to impairment of vision and of blindness due to ophthalmia neonatorum are more valuable. In the past 20 years there has been a gratifying decline in both, especially in the last few years: for this the introduction of the sulphonamides may well be responsible. The figures for London and Scotland, where the rate of blindness so caused is 0.4 per 100,000 births, are comparable. Then follow, each in turn less favourable, the

figures for the Administrative Counties of England, the English County Boroughs and the whole of Wales.

In the clinical section the subject is considered from the standpoint of aetiology, prophylaxis and treatment. Whatever may have obtained in the past, Professor Sorsby points out that the main cause of ophthalmia neonatorum to-day is not gonorrhoea. In his experience the causative factors are: gonococci 25 per cent, staphylococci 35 per cent, other cocci 5 per cent, various bacilli 20 per cent, virus 10 per cent, undetermined 5 per cent. Following Crede's silver nitrate prophylaxis there was a great reduction in the incidence of ophthalmia neonatorum. But this reduction has not been progressive. There is reason to believe that ophthalmia neonatorum is no less frequent to-day than it was 25 and possibly 40 years ago. This, he considers to be due to undue emphasis placed upon gonorrhoea as a cause in the past to the comparative neglect of prophylactic treatment of maternal infections other than gonorrhoea. The recognition of a virus-type of ophthalmia neonatorum and a causative virus-cervicitis would confirm this. So, too, would the suggestion that the chemical component of the Crede prophylaxis is probably not effective against organisms other than the gonococcus. For combating the occurrence of gonococcal ophthalmia neonatorum *routine* tests at antenatal clinics for the detection of maternal gonorrhoea are advocated. The merits of silver nitrate and other chemicals used as prophylactics are considered in some detail.

The section on treatment of the established condition will repay careful study. Sulphonamide therapy is shown clearly to be superior to the classical methods of treatment. While gonococcal cases respond most readily, there would seem to be no particular variety of non-gonococcal case which fails to respond to this treatment. The effi-

cacy of the different sulphonamides is compared. Sulphamezathine is probably the most useful as a routine measure. Sulphanilamide was given up because of unpleasant toxic effects. Oral administration is distinctly superior to local application.

The early experiments in treatment with penicillin are described, leading finally to intensive local treatment with a concentration of 2,500 units per cubic centimetre. Such penicillin treatment has been found to be as superior to sulphonamide therapy as that is to the classical methods.

This most valuable monograph should certainly be read by all who practise obstetrics, or who undertake the care of the newborn. Those who have seen the devastating effects of severe ophthalmia neonatorum appreciate fully the importance of prompt and expert treatment. In this paper we are presented with considered conclusions from the unrivalled experience of an acknowledged expert.

To the obstetrician, Professor Sorsby emphasizes that in the prevention of ophthalmia neonatorum the treatment of maternal leucorrhoea of non-gonoccal origin is as important as that of maternal gonorrhoea.

Two quotations deserve attention:

(a) First, to remove, if possible, the disease in the mother during pregnancy; secondly, if that cannot be accomplished, to remove artificially as much of the discharge as possible from the vagina at the time of delivery; and third, to pay, at all events, particular attention to the eyes of the child by washing them immediately after delivery with a liquid calculated to remove the offending matter or to prevent its noxious action." (Benjamin Gibson, *Edin. Med. and Surg. Journ.*, 1807, p. 160, quoted by Sorsby.)

(b) "The prevention of ophthalmia neonatorum lies in the first place in the treatment of the expectant mother, and this would as yet seem to be an aspiration rather than the reality. How much of an aspiration and how little of a reality is only too clearly shown by the fact that the majority of births in this country do not have the benefit of medical attendance, while antenatal attention is still the exception rather than the rule." (Sorsby, 1945.)

There is a curious similarity in these utterances; after 138 years a challengingly curious similarity.

ANTHONY W. PURDIE.

REVIEWS OF HOSPITAL REPORTS

MEDICAL AND CLINICAL REPORT OF THE SIMPSON MEMORIAL MATERNITY PAVILION, ROYAL INFIRMARY, EDIN- BURGH, FOR THE YEAR 1944.

THE report is concerned mainly with 3,875 patients treated in the hospital. There is a brief summary of 794 patients delivered in their own homes. There is also a paediatric section. The maternal report deals with the patients discharged during the year while the paediatric report deals with infants born during the year.

There was a total of 18 maternal deaths—2 unbooked patients died undelivered, of delivered patients 5 booked and 6 unbooked died in the hospital, while 5 patients (4 booked and 1 unbooked) died after transfer to the City Fever Hospital. The deaths in hospital among booked cases all appear to have been unavoidable—3 of mitral stenosis and heart failure (grade III), 1 of tuberculous meningitis, and 1 of acute heart failure with acute pulmonary oedema 2 hours after delivery. Death in unbooked cases in hospital were from eclampsia 2, rupture of the uterus 2, puerperal sepsis 2, acute bronchopneumonia 1, and acute suppurative pyelonephritis 1. Of these 2, and possibly 3 appear to have been unavoidable, while in 4, where death appears to have been unavoidable after admission to hospital, with some or improved antenatal care death might have been avoided. Of those transferred to the City Fever Hospital, 4 died of sepsis (1 after childbirth and 3 after abortion) at intervals varying from 10 days to 3 months following delivery or abortion. It is interesting to note that one postabortal case showed the rare condition of general peritonitis due to an anaerobic streptococcus.

Of 25 patients who had eclampsia 2 (8 per cent), died. Quite a considerable amount of information is given about this condition. But in all 25 cases the treatment is described as 'sedatives.' It would

have been more instructive had the sedatives used in each case been named. Caesarean section was the mode of delivery in 2 cases, but the reason for the choice is not given. Pre-eclamptic toxæmia was diagnosed in 267 cases (6.8 per cent) and essential hypertension in 43 cases. The standards for these diagnoses are not given.

Placenta praevia occurred 56 times. There was no maternal death. Of 59 infants (3 twins), 16 failed to survive. Of these 16, 11 were of less than 36 weeks' maturity and so were excluded in calculation of the foetal survival-rate. Hence it is said that of the remaining 48 infants 43, or 89.5 per cent, survived. As 26 of the 59 infants were of under 36 weeks' maturity the only reason for the exclusion of the 11 was that they failed to survive. In this condition the infant's prematurity is due to the placenta's being praevia. It seems desirable, therefore, to include all infants in estimating foetal results except where there is present some congenital abnormality which, in itself, is incompatible with life. Viewed in this light the foetal survival-rate is 73.8 per cent.

Among the cases of multiple pregnancy was 1 (booked) of quadruplets. The mother had hypertension. Unfortunately premature labour occurred at 28 weeks. All 4 infants died.

Caesarean section was performed 166 times—5 per cent of all hospital deliveries. There were 3 maternal deaths (1.8 per cent). The foetal mortality was 22 (13 per cent). The main indications, foetal deaths and maternal deaths are tabulated, but not with single case details. In those instances where foetal death was highest the main indications for the Caesarean section were placenta praevia 4, primary (uterine) inertia 4, bad obstetric history 3, severe pre-eclampsia 3.

The incidence of 'failed forceps outside' seems high. There were 12 cases. In hospital only 2 of these were delivered spontaneously. Of the remainder 8 required forceps delivery, 1 Caesarean

section with hysterectomy, while 1 was delivered by internal version and breech extraction. There was not any maternal death. In 9 the child survived, in 4 stillbirth is said to have occurred (1 set of twins), but there is an error in this table, as the figures do not tally.

In 50 cases of uncomplicated primigravid breech delivery the foetal mortality was 3 (6 per cent).

The paediatric section is tabulated but comprehensive. The neonatal death-rate for all infants was 24 per 1,000 viable births and the stillbirth-rate 44.2 per 1,000 viable births. The cause of death was considered to be known in 71 of the 73 fatal cases and confirmed by postmortem examination in 64 cases. The cause of stillbirth was known in 81 of the 133 cases. It was determined by post-mortem examination in 70 cases and by evident congenital defects in 11. Neonatal deaths, morbidity and stillbirths are analysed in considerable detail.

ANTHONY W. PURDIE.

THE MEDICAL AND CLINICAL REPORT OF THE WOMEN'S HOSPITAL, CROWN STREET, SYDNEY, 1943-44.

This report deals with the patients in the public wards of this hospital from July 1st, 1943, to June 30th, 1944. As a wartime economy many detailed tables of cases formerly published are replaced by summaries of results. The complete tables have been drawn up, however, and are available to anyone requiring them.

There were 5,254 admissions: 356 to the gynaecological department, 4,004 to the indoor maternity department, and 894 to the isolation department (Founders' Block). In the hospital 3,342 women were delivered of 3,376 babies, while 40 confinements resulting in the birth of 40 babies took place in the district. Out-patient attendances numbered 30,210 for adults and 947 for infants; of these 6,495 and 407 respectively were new cases.

Single case data of maternal conditions are given in complicated breech, eclampsia, antepartum haemorrhage, prolapsed cord, cardiac disease, multiple pregnancy, Caesarean section, version in labour, destructive operations and severe morbidity. The same is done with neonatal deaths and stillbirths. Other maternal and foetal con-

ditions are shown in condensed tabular form. A detailed summary is given of each maternal death.

This condensation necessarily means that important information is withheld. For example out of 105 cases of uncomplicated breech delivery 33 babies (31.4 per cent) were stillborn or died. It is not stated how many of the patients were primigravidae and multigravidae.

Placenta praevia occurred 32 times. There was no maternal death, but 22 babies (68.7 per cent) died or were stillborn. It is interesting to observe of the 10 babies who survived that the maternal treatment was Caesarean section 3, artificial rupture of the membranes 1, medical induction (drug only presumably) 1, and in 4 rest, conservative or expectant. In other words only those babies survived whose mothers were treated by Caesarean section or artificial rupture of the membranes, or who did not require any treatment at all.

The toxæmic problem is recorded only partially. Albuminuria (without eclampsia) occurred in 149 patients. But there is no mention of hypertension without albuminuria. Yet this is a major consideration in any obstetric department. As some of these patients require to have labour induced, it might be supposed that further information could be deduced from study of the table dealing with induction of labour. But this is not so. Here we find that induction was attempted in 151 cases. The methods used were 'medical,' 'artificial rupture of membranes,' 'medical with artificial rupture of membranes' and 'surgical (with or without medical).' The indications for the inductions are not given. What does 'surgical' mean?

Caesarean section was performed 45 times with 4 (9.9 per cent) maternal deaths. Of 46 children delivered 4 failed to survive. Of these 4 rupture of the uterus was the maternal complication in 2, and failed forceps before admission in 1; in the last the child is considered to have died from cerebral anoxaemia.

Maternal morbidity for the whole obstetric department is 5.6 per cent. This is said to be reckoned on the British Ministry of Health standard. That standard, however, is defined erroneously. This section is confusing probably because of inaccuracies. The total number of cases recorded as morbid is 187, yet the number of cases of local uterine infection with temperature over 101°F. is

given as 198. Septicaemia is diagnosed in 3 cases; in one the diagnosis was proved by autopsy, but the other 2 patients survived and in these it would seem that blood culture was either negative or not done at all.

Excluding those patients admitted direct to the isolation department there were 13 maternal deaths in the obstetric department. Of these 5 occurred among booked cases—2 of sepsis, 1 of pulmonary embolism, 1 of ruptured uterus; in the remaining 1, Caesarean section would appear to have been indicated as she died undelivered following attempted forceps operation and then craniotomy. The remaining 8 deaths occurred among emergency cases. Eclampsia was responsible for 4, pneumonia for 1, paralytic ileus following Caesarean section for 1, post-partum haemorrhage for 1, and pulmonary embolism following 'failed forceps outside' and extraperitoneal Caesarean section for the last.

The Infants' Report deals with the babies born in the hospital. The number of these is not quite clear. It is given as 3,376 (page 7) and 3,386 (pages 31 and 32). Calculations are based on the latter figure. The stillbirth-rate is 34.5 per 1,000 births or 22 per 1,000 births at term if premature and non-viable infants are excluded. Similarly the neonatal death-rate is 29 per 1,000 live births or 9 per 1,000 live births when the same correction is made. The combined stillbirth and neonatal death-rate is 62.9 per 1,000 births: when similarly corrected the figure is given as 37.8 per 1,000 births

at term. The term 'non-viable' is not defined. Of 250 premature infants born 69 (27 per cent) died.

It is not stated in the infants' report on which cases of stillbirth and neonatal death the cause attributed was confirmed by postmortem examination. This is to be regretted for some of the causes stated are likely to be quite inaccurate if the diagnosis were made on clinical grounds alone. From the report of the Pathology Department it is found that 61 infant autopsies were performed—that is 28.6 per cent.

There is a busy Isolation Department. Here 894 patients were discharged in the year, excluding 163 patients transferred from the maternity department. This block deals with abortions, obstetric sepsis and gynaecological cases with a septic element. Maternal death (excluding 2 cases included in the obstetric department figures) occurred 10 times—all in abortions. Of these 8 were due to sepsis (only 7 are listed in the table of postabortal sepsis (page 44) and 2 to tetanus.

Numerical analyses follow of the work of the Gynaecological, Pathological, X-ray, and Almoner's Departments. A striking figure is the low incidence of carcinoma of the uterine cervix. There were only 2 cases. This is so small a number that it suggests routine admission of such cases elsewhere. The report does not comment on the figure.

This is an exhaustive report which has been shorn of much information to condense it as a wartime measure.

ANTHONY W. PURDIE.

INDEX TO CURRENT LITERATURE

In this Index an endeavour will be made, so far as conditions permit, to maintain an up-to-date record of all titles bearing on obstetrics and gynaecology and the infant. The classification aims at making immediately available for the reader the titles under the various subject headings. In the majority of instances the title is obtained from the original publication. Where this has been impossible, the title has been obtained from the abstracting journal shown in brackets. Reprints will be welcomed and should be sent to the Editor.

Any inquiries should be addressed to Miss D. F. Atkins, British Post-graduate Medical School, Ducane Road, London, W.12.

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PHYSIOLOGY

1. "Solubilité de la progestérone dans le sang." (Solubility of progesterone in blood.) G. Masson and H. Selye. *Rev. Canad. Biol.*, 1945, IV, 193-6.
2. "Thermogenic effect of progesterone." M. Barton and B. P. Wiesner. *Lancet*, November 24th, 1945, II, 671-2.
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5. "Estudio experimental y clínico de la influencia de la glándula tiroides sobre el ovario." (Experimental and clinical investigation of the influence of the thyroid gland on the ovary.) L. A. Arrighi. *Obstet. y Ginec. Latin-Amer.*, June 1945, III, 418-35.

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PREGNANCY

NORMAL

Physiology

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9. "Studies on serum iron. I. Serum iron in healthy women during the latter part of pregnancy, parturition and puerperium." S. Dahl. *Monatsschr. f. Geburtsh. u. Gynäk.*, June 1945, CXIX, 281-303.

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Abortion

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See also Ref. 70, 71.

Association with disturbances of the reproductive system

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LABOUR

NORMAL

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IN MEMORIAM

GEORGE HAROLD ARTHUR COMYNS BERKELEY
M.A., M.D., M.C. (Cantab.), F.R.C.P., F.R.C.S., F.R.C.O.G., M.M.S.A. (Hon.).

1865—1946

Sir Comyns Berkeley

COMYNS BERKELEY's services to this Journal as Honorary Editor covered the long period from October 1919 until his death in January 1946; during the last three years James Young was associated with him as Joint-Editor. His services were of inestimable value, and they merit full recognition at the hour of his death.

The Journal was founded in 1902 and financed by a small number of men interested in our subject, drawn from all parts of the United Kingdom, who subscribed a modest sum as working capital by taking shares in the private company established for the purpose. It is not surprising that a loss on publication was recorded every year until, when the first Great War broke out in 1914, the Directors judged it to be necessary to suspend publication at once. The Journal was then heavily in debt to the Publishers, who with faith in its future and with great public spirit agreed to carry the debt without charge to the Company. It was not until the autumn of 1919, 5 years after, that it was thought practicable to make an effort to resume publication. The somewhat thankless task of Editorship having been declined by a number of men was finally offered to Comyns Berkeley as the sort of man most likely to make a success of a lost cause. He accepted it and did not disappoint the expectations of his friends, for it is not too much to say that the present position of the Journal is due to his untiring efforts, more than to the work of any other man.

The first concern of the Editor and the new Board of Directors was to make the reappearance of the Journal as widely and as quickly known as possible and, with this object, money was lavishly spent in distributing free copies of the new first issue to all old subscribers who could be traced, and to a large number of prospective new subscribers. This bold policy reaped an immediate reward, and the new list of subscribers grew steadily year by year, with hardly a set-back until a record number was reached in 1945. The Editor and the Board keenly felt the obligation of repaying the debt to the publishers, but it was not until 1932 that this debit finally disappeared from the Balance Sheet.

Thus was the apparently dead brought to life again, and the major share of credit for this act of resuscitation undoubtedly is due to Berkeley and to his patient and sustained editorial work. It must have been a great satisfaction to Berkeley to see his work eventually come to fruition. His Journal now occupies a prominent position among the medical periodicals

of the world, it circulates all around the globe, and attracts contributors and subscribers not only from all parts of the British Empire, but from many foreign lands as well.

In these early years Berkeley's task was indeed arduous and exacting and, when one remembers the many other literary hostages he had given to fortune at that period, it is clear that only a man of quite uncommon capacity for work could have ever dreamed of undertaking it. But Berkeley was indeed one of the hardest workers I have ever known; he worked because he loved work, and was deeply interested in all that he undertook. He worked not in bursts of high activity but by continuous application, supported by a high degree of conscientiousness. His friends sometimes thought that he devoted time to tasks which were hardly worthy of his attention, such as correcting proofs, and on occasions he has told the present writer that he had spent several hours in correcting MSS. sent by a foreign contributor whose ability to express himself clearly in English fell far short of an English editor's standards. His editorial work was the more exacting because he did not make use of such time-saving devices as the employment of a secretary or the delegation of proof-correcting to a sub-editor. One or two of his personal friends gave him assistance in this latter task, but he always took a large share upon himself. His day-time hours were fully occupied with other work, and accordingly he worked for the Journal far into the night, in solitude. His caligraphy was never clear, and at times was almost undecipherable, even to those who had struggled with it for many years. He learned to use a typewriter, but never became a quick or accurate typist.

One of his most difficult tasks at this period was to obtain original articles for publication, and he wrote numberless holograph letters to his friends and acquaintances begging them to send their work to him for publication. At first these appeals met with only partial success, but members of the Board of Directors came to his assistance, and although some of the issues were late in appearing, none was ever entirely missed.

Outside his editorial work for the Journal, Berkeley undertook many literary tasks, sometimes alone, sometimes in collaboration. Perhaps his best work was done in association with his colleague and friend, Victor Bonney, to which tribute has been paid elsewhere. It is not too much to say that their *Text-Book of Gynaecological Surgery* has attained the status of an English medical classic. Then there is the astonishing enterprise of the *Ten Teachers*, the two volumes of which are now in their seventh edition. Berkeley acted as Editor from their first appearance onward, not only keeping his team of highly individualistic experts together, but maintaining their work in both Midwifery and Gynaecology at a high level of popularity and educational value. Only a man endowed with rare personal qualities could have succeeded in such a task. Taking it all in all, Berkeley's literary output was enormous, and must have taken heavy toll of his physical strength although he appeared always to be working well within his powers. It was not until the last few years of his life that signs of strain appeared,

aggravated undoubtedly by war-time anxieties. Not only was his professional residence badly damaged by enemy action, but the health of his wife, to whom he was entirely devoted, broke down, and thereafter he willingly gave up much of his time to provide companionship for her. His friends saw with anxiety that he was becoming a very tired man, but either he did not realize it, or refused to admit it even to himself. The courage with which he carried on all his engagements throughout the period of the war was a revelation of his character which those who worked with him then will not easily forget.

No account of Berkeley's activities would be complete without reference to the part he took in bringing into existence the College of Obstetricians and Gynaecologists, now the Royal College. He was a prominent member of a group of men from all parts of the Empire who worked together in planning the first outlines of its organization. It speedily became clear that the proposal would receive the adhesion and support of almost every British teacher of these subjects not only at home but in all parts of the Empire. Berkeley was an enthusiastic advocate of the scheme, and on the foundation of the College, in 1929, he became one of the signatories to the Articles of Association, and its first Treasurer, Blair Bell having been elected by his co-signatories as the first President. Unhappily, differences very soon arose upon financial matters between members of the Council which made such a deep impression on his perhaps over-sensitive mind that he felt compelled to resign the office of Treasurer and with it his *ex-officio* seat on the Council. This occurrence was a great grief to Berkeley and to many of his friends, for there is no doubt that in happier circumstances he would have brought to the College the generous and unstinted service which was so characteristic of him.

Always interested in the training, the work and the welfare of Midwives, he became a member of the Central Midwives' Board in 1930, and in 1936 he succeeded Dr. J. S. Fairbairn as its Chairman. He was always an active member of the Board, and he took a prominent part in introducing new regulations for the qualifying examination for the State Registered Midwife. When the second Great War broke out he was busily engaged in forwarding a plan for a qualifying examination for "Assistant Midwives". This work was of necessity abandoned, but Berkeley had not given up hope of returning to it later on, and there is no doubt he would have done so had his life been further prolonged.

In 1934 King George V conferred upon him the honour of Knight Bachelor. This recognition of his outstanding services to the department of medicine to which his strenuous life had been devoted was universally felt to be a well-deserved tribute to his work and to his character. To his innumerable friends it gave real joy and to himself a deep satisfaction which was characteristically frank and unconcealed.

T. WATTS EDEN

GEORGE HAROLD ARTHUR COMYNS BERKELEY, who died on January 27th, was born on October 16th, 1865; the eldest son of George Augustus Berkeley and Sarah Louisa, second daughter of Thomas Moore of The Wergs, Wolverhampton. His father was descended from the Berkeleys of Cotheridge Court, Worcester, an offshoot in 1512 of the Berkeleys of Spetchley, Worcester, and through these two families George Comyns was kin both to Earl Berkeley and Lord Fitzhardinge.

Comyns, the name by which he was most usually known, commemorated the family of his great-grandmother, who was a daughter of John Richard Comyns of Hylands, Essex.

At the age of 13 he went to Marlborough School, and from there to Caius College, Cambridge, where he took the B.A. (Natural Science Tripos) in 1888. He then entered the Medical School of Middlesex Hospital and became M.B., B.Ch., in 1902. Thereafter he was successively house physician to Dr. (afterwards Sir) Richard Douglas Powell, house surgeon to Mr. (afterwards Sir) Henry Morris, and obstetric house surgeon to Dr. William Duncan. He also held house physicianships at the Brompton Hospital for Diseases of the Chest, and the Great Ormond Street Hospital for Sick Children. I, as a young student, remember him as a thin young man with fair hair and rather prominent blue eyes.

His special interest in obstetrics and gynaecology evolved during his term of obstetric house-surgeonship, for he began to hold coaching classes for the "Midder" Examinations. They became very popular, and he used to say he had coached men of every nationality except an Eskimo.

In April 1894 he married Ethel Rose, youngest daughter of Edward King Fordham, D.L., J.P., of Ashwell Bury, Herts, and took a lease of 53 Wimpole Street, the house wherein he died 52 years later.

In 1893 the then medical staff of Chelsea Hospital for Women resigned, pending an investigation into certain allegations made against the institution. As a result of this enquiry in 1895 a new staff was appointed which included Dr. William Duncan and Mr. (as he then was) Bland Sutton. Berkeley was made surgical registrar, and 2 years after he was elected an assistant physician. It is to be remembered that in the nineties very few gynaecologists in this country had undergone a full surgical training: they were physicians on to whom a certain amount of surgical knowledge had been grafted. They were styled Dr., not Mr., counted as members of the medical, not the surgical staff, and at several hospitals they were not permitted to perform abdominal section. William Duncan was, however, F.R.C.S. England, and Berkeley had worked both under him and under Bland Sutton before he came to Chelsea, so he had already been introduced to the high standard of gynaecological surgery for which that hospital speedily became famous. I went to Chelsea Hospital for Women as resident

officer in 1898, and so began an association with Berkeley which lasted for 48 years.

In 1901 an obstetric registrarship was created at Middlesex Hospital, and the election proved a momentous one, for, besides Berkeley, Hubert Roberts from St. Bartholomew's Hospital was a candidate, and he was very strongly backed by a certain group of the medical committee. In those days only two of the honorary staff of the hospital had been trained at Middlesex and the staff was divided into two cliques, one favouring outsiders while the other desired more home-grown products. Berkeley was elected by one vote, and time was to prove how fortunate it was, for his election opened his way to the honorary staff whereon he rendered such outstanding service to the hospital.

In 1905 the retirement of Robert Boxall made a vacancy, and Berkeley became assistant obstetric and gynaecological surgeon, while I, who in 1901 had been placed on the honorary staff of Chelsea Hospital for Women, succeeded him as obstetric registrar and tutor. In 1908 William Duncan retired and Berkeley became the head of his department, while I became second-in-command, and for the next 23 years we stood in that relationship. He retired from active work at Chelsea in 1925, and from Middlesex in 1930, having worked at the former institution for 30 years and at the latter (counting his studentship) for 42 years.

The amount of work he accomplished during his life is so large and various that it can best be described in several categories. Taking Middlesex first, from his student days he played a leading part in the social activities of the hospital. Infantile paralysis as a child debarred him from the more strenuous forms of sport, but he was zealous in promoting them, and for many years took a cricket team down to Ashwell to play against the local eleven. He was foremost at all convivial gatherings and sang a good comic song: *Sipping Cider Through a Straw-haw-haw* was, I remember, his *pièce de résistance*. He was the leading spirit and treasurer of the Middlesex Hospital Club, and, with the late Herbert Charles (for so many years his anaesthetist), he initiated the annual smoking concert and annual dance. When the Middlesex Hospital Lodge was founded he was one of its earliest members, and he remained active in the craft for many years.

His good humour, tact, and sterling judgment made him an ideal committee-man, and throughout the years of his service at Middlesex he took part in every meeting concerned with the welfare and advancement of the hospital. He taught assiduously up to the day of his retirement with a simplicity and common sense which appealed at once to the students' understanding. Nor was this all; many men from many generations of students owe him gratitude for sound advice and ungrudging help at times of doubt or trouble.

As regards his professional work at his major hospital, his tenure of seniority (23 years) gave him time to carry through great improvements in his department. The number of its surgical beds was considerably increased, a special operating theatre built, a handsome maternity depart-

ment and a training school for midwives were added, a flourishing antenatal clinic took shape, the extern midwifery service was reorganized, and a closer liaison between the pathological and biochemical departments was established. He operated two days a week in his own theatre, and the number of operations he performed there must have run into many thousands.

At Chelsea Hospital for Women he played a full part in the surgical work. Our team-work began there and is chiefly notable for our association with Wertheim's operation. The operation was first performed in this country by Cuthbert Lockyer in 1905, and in 1906 I, assisted by Berkeley, attempted it, but found the growth too far advanced. I succeeded, however, twice in 1907, and in 1908 (the third case in our series) Berkeley successfully accomplished it with me as assistant. Thereafter, for many years, with one or the other of us as principal, we performed it together and from time to time published our results. When that collaboration came to an end Berkeley unfortunately failed to keep in sufficient touch with his personal patients, and lost sight of so many of them that he was never able to publish authoritative figures, although he had performed the operation in all between 300 and 400 times.

Besides the two hospitals already named, he was for many years attached to the City of London Maternity Hospital, and there, too, rendered services far beyond his strictly professional work.

Throughout the 1914-18 war he and I were the surgeons of the Middlesex War Hospital, Eastern Command, at Clacton-on-Sea. The building was the handsome Middlesex Hospital Convalescent Home, which was emptied for the purpose and staffed entirely from the hospital in town, though we were under the aegis of military headquarters at Colchester. It was a base hospital, and we received convoys of wounded men direct from France and Flanders, who, as they became convalescent, were distributed to the various Red Cross Hospitals in Essex and Suffolk. Altogether some 10,000 men passed through our hands, and we did a great deal of major surgery during the 4½ years we stayed there. As the work at Middlesex and its medical school and at Chelsea Hospital for Women had to be kept going, we arranged for each of us to spend half the week at Clacton and half in London. The half-week in London, when each had to do the other's work as well as his own, was very strenuous. The position we held was curious in two respects: firstly, though we were under the Army we were not of it; and secondly, we got no pay, and, what at that time was still more important, no ration allowance! Later we summarized our experiences in a book which was published by the Middlesex Hospital.

Berkeley's accomplishment as an examiner was unique, comprising the Universities of Birmingham, Bristol, Cambridge, Leeds, Liverpool, London, St. Andrew's, Sheffield, Manchester, and Wales, the Conjoint Board and Apothecaries' Hall. Quite unjustly he was rather feared by many examinees on account of a certain rough joking manner, but actually, as I know from personal experience, he was both kindhearted and lenient.

He was early concerned with the development of radiotherapy, and became the director of the Metropolitan Asylums Board Radium Clinic, later taken over by the London County Council. He was one of the original members and Vice-Chairman of the National Radium Commission, and he represented this country on the Radiological Sub-Commission of the League of Nations, of which he was trustee and Vice-Chairman, making several official tours around the centres in Europe.

During the later years of his life he was closely associated with the Ministry of Health in the production of the Maternal Mortality Reports of 1930 and 1932.

From his early days the nursing profession was one of his great interests. He was Treasurer of the Royal British Nurses Association for 21 years, and afterwards of the Royal College of Nursing, which he helped to form, and he held the same position to the Cowdray Club for Nurses.

For a long time he was one of the examiners of the Central Midwives Board; later he was on the Board as representative of the Royal College of Physicians, and in 1936 succeeded Fairbairn as its Chairman, a post which he held up to his death.

Though he wrote very few individual papers and rarely spoke at meetings, his literary output was very large. He and I collaborated to produce "A Textbook of Gynaecological Surgery," "The Difficulties and Emergencies of Obstetric Practice," "Gynaecology in General Practice," and (with Douglas Macleod added) "The Abnormal in Obstetrics," the last as late as 1938. The idea of writing the first of these books took shape in 1905, but neither of us could then afford the heavy expenses of a professional artist, so I had to teach myself to draw, a process so slow that the first edition of the book did not appear until 1911. The text was written between 9 p.m. and 2 a.m., and at each sitting we consumed a bottle of old port from Berkeley's well-stocked cellar to keep us awake!

Besides these books, he wrote "A Handbook for Midwives and Obstetric Dressers," "Gynaecology for Nurses," and "Pictorial Midwifery," all of which have gone through a number of editions. For many years he was the editor of the "Ten Teachers' Midwifery" and the "Ten Teachers' Gynaecology," the idea of these combined efforts having originated with him, and he also contributed to several of the encyclopaedias. This Journal owes a great debt to him, for he edited it for 23 years, during which period its reputation, both at home and abroad, steadily grew. Others are more competent to speak of this aspect of his activity than I am.

The foregoing pictures a prodigious life's work. What of the man? Berkeley possessed in exceptional degree a native humour, a geniality, a tolerance and a kindness of heart which procured him a multitude of friends. A *bon-viveur* by nature and inheritance, he was invaluable at any gathering where fun and good-fellowship were called for. He had an intense relish for the pleasant things of life, and revelled in good company, especially when it was intimate and gossipy. He was keen on golf and shooting, and attained fair proficiency at each until an accident to his knee prevented

either. He had travelled in many parts of the world. His domestic life up to the last few years was exceptionally happy, and his house, so perfectly presided over by his wife, was a byword for hospitality. He was an expert in good fare and good wine, and entertained royally both at home and at the Garrick Club, of which he was an old member. Many there be who will remember those dinners and suppers with affectionate regret.

Misfortune beset him at the end. His beloved wife's mind broke down, but he was resolute not to part from her. His house in Wimpole Street was shattered by a bomb, and so was the house in Hampstead to which he removed, and his own health began to fail. The death of his wife was the culminating blow, for he had outlived all his relatives and was quite alone. Nevertheless, with indomitable courage he stuck it out, and continued editing his Journal and presiding over his Board until the end came.

Our calling has lost an outstanding figure and many of us a dear friend, whose life exemplifies what immense possibility there is in unfaltering persistence, and teaches us that time is much more spacious than most of us are apt to think, there being within it, if fully utilized, ample room both for great work and great play.

VICTOR BONNEY

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The Control of Infection in Obstetrics

BY

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Being the William Blair-Bell Memorial Lecture, delivered at the Royal
College of Obstetricians and Gynaecologists, January 25th, 1946.

LOOKING back over the recent war years it seems profitable to consider how far the study of wound infections—in particular of streptococcal infections—may contribute to our understanding of puerperal fever.

Before taking up that question I would, however, like to make the point that the coming of penicillin and the sulphonamides does not constitute any ground for complacency in the matter of puerperal infection. The control of streptococcal infection is still a major issue in obstetrics. Although the mortality from these infections is much reduced, their incidence is still too high. From figures kindly supplied to me by Dr. Robert Cruickshank and Dr. Letitia Fairfield, and from the weekly returns published in the *British Medical Journal*, it would appear that there are rather more than 7,000 cases of notified puerperal pyrexia per annum in England and Wales at the present time, and of these, not less than 700 are infections by haemolytic streptococci. It is probable that the true figures would be considerably higher.

It has been suggested that these strepto-

cocci are likely to die out under the influence of the new chemotherapeutic drugs. That seems to me improbable for several reasons:

- (1) This streptococcus is particularly well adapted for growth in the blood and tissue fluids of human beings.
- (2) Although its virulence for man has been declining during the past 40 or 50 years, as shown by the mortality of scarlet fever, there is no assurance that this phase will inevitably continue. We know too little about what determines periodic changes in virulence.
- (3) There is now abundant evidence that these streptococci are able to adapt their metabolic processes for survival in the presence of the sulphonamides, and it has been my experience that, when so adjusted, that is, when they have become 'resistant' to these drugs, they are particularly liable to epidemic spread among human beings. That has already happened in several surgical centres

in this country^{1, 2}. In America an important account has recently been published³ of a major epidemic of streptococcal disease which coincided with the development of sulphonamide resistance in streptococcal strains (Types 19 and 17) in a camp where naval trainees had been given sulphadiazine prophylaxis for the prevention of respiratory infections. It may well be that the next few years will see a wide dispersal of these resistant strains all over the world—an event which might have serious consequences.

No such adaptation to penicillin has yet been recorded, so far as I know, in the case of the haemolytic streptococcus, but since it occurs readily with staphylococcus, both *in vitro* and *in vivo*, we should be rash to assume that it can never happen with streptococci.

Finally, before I leave this aspect of the matter, may I urge the importance of maintaining our vigilance against these unseen enemies of the parturient woman? If we do not go forward in our preventive procedures, we shall probably go backward. We have seen that happen in surgery within the 30 years preceding this last war. In the early days of this century the "no-touch technique" and the careful dressing of wounds with an overall covering of wool as a protective covering to keep out infection were part of the standard teaching of surgeons, but during the first Great War, in the stress of dealing with enormous numbers of casualties, these preventive measures gradually ceased to be standard practice and a generation arose after the war which did not realize their importance. It became necessary to re-introduce a strict no-touch technique in dressings as something new during the last war. In my view it is still our business to improve continually our preventive measures in obstetrics

by blocking all the channels along which infection may be transmitted.

To-day I want to speak about one such channel to which we have perhaps paid too little attention, viz. aerial transmission. That possibility has, of course, been more or less in view ever since Lister, following Pasteur, directed attention to its importance in surgery, but the emphasis upon it has fluctuated with the output of evidence—and with the recognition of other possible paths of infection. Thus, between 1890 and 1910 the work of Flügge⁴, Koeniger⁵, and others on the Continent, and of Mervyn Gordon⁶ in this country, convinced many of the inherent dangers of air-borne bacteria; but in 1910 Winslow and Robinson⁷, after a long series of experiments, threw some doubt upon its practical importance. At about the same time the risk of contact infection was being re-asserted in surgery; rubber gloves began to be worn; and an aseptic as well as antiseptic ritual in the operating theatre was developed.

In so far as aerial transmission was in men's minds at this time it was chiefly visualized as direct transmission by salivary spray from the mouth. Somewhat later the work of Wells⁸ accustomed us to the conception of minute 'droplet nuclei' which could remain suspended in the air and carry infection to considerable distances from the original source. Against these dangers the wearing of efficient masks offered some degree of protection.

Gradually, after the first World War, as bacteriologists made progress in the differentiation of the pathogenic cocci, particularly of the haemolytic streptococci (Dochez⁹ *et al.*, Griffith¹⁰, Lancefield¹¹), this danger of transmission of organisms from the respiratory tract came more and more into prominence. The wearing of masks became general. In obstetrics, with the work of Smith¹² of Aberdeen, of Hedley Wright and others¹³ in London, and in

particular of my sister, Dora Colebrook¹⁴, at Queen Charlotte's, we began to get a body of evidence pointing to the respiratory tract as the probable, or possible, source of many puerperal infections. You will recall that, in 76 per cent of a series of 67 outbreaks or individual cases investigated by my sister, she found a streptococcus serologically identical with that of the mother's genital tract strain in some extra-genital situation—usually the respiratory tract—of somebody, either an attendant, or the mother herself, or a member of her family. My sister refers to these extra-genital situations as *possible* sources of the streptococci which actually infected the mother. I felt at the time that the evidence justified using the word '*probable*', but she was more cautious and preferred '*possible*'. Whatever view we take about the degree of probability, the significance of my sister's findings can hardly be doubted, but she herself would be the first to admit that they did not tell us the whole story. They did not pretend to throw any light upon the question "How precisely did the streptococci pass from the extra-genital place of origin to the genital tract of the mother?" Was it by direct droplet spray from the throat or nose of the individual carrying the organism, or was it by a more indirect route, via somebody's hands or clothes, or possibly by way of dust? We have perhaps been too much inclined to assume that the more direct transmission by droplet spray was the common event, but evidence that has come in recent years suggests to me a different view, namely that indirect transmission has probably played an important part. This is an issue of considerable practical importance, in obstetrics as well as in surgery and medicine, because the planning of appropriate preventive measures largely depends upon it.

If the respiratory tract is the common place of origin of the streptococci, and

transfer is usually by direct droplet spray, the wearing of efficient masks should usually be an adequate protection. If, on the other hand, streptococci from the respiratory tract, or from foci of infection elsewhere in the body, are frequently deposited upon dust particles and dispersed through the air in that medium to situations quite remote from their place of origin, then clearly masking will often fail to give protection, and we need to consider measures specifically directed to the elimination of dust in planning for maximum safety in maternity work.

It is this last possibility and the appropriate counter-measures that I want to discuss with you to-day. So far as I know, the first demonstration that haemolytic streptococci may sometimes be found in the air of hospital wards* was given by R. Cruickshank¹⁶. He showed that the air of the Burns Ward at the Glasgow Royal Infirmary, which housed many patients infected with streptococci, was often contaminated by those organisms, sometimes in considerable numbers; whereas that of the general surgical wards in the same hospital yielded few or none, and he failed to grow any from the air of the medical wards.

At the Isolation Block of Queen Charlotte's we were able to repeat these observations in our single-bedded wards, some of which housed patients with a streptococcal infection while some did not. In a valuable paper "on the possible transmission of haemolytic streptococci by dust"¹⁷, my colleague, Elizabeth White, reported that on all of 27 occasions a series of plates exposed in a ward with a streptococcus-infected patient yielded 1 or more colonies of haemolytic streptococcus (on 22 occasions there were 6 or more), whereas a

*They were reported in the air of military quarters during the pandemic of 1918-19 by Huddleson & Hull¹⁵.

similar series of plates exposed in 6 wards where the patient had not a streptococcal infection yielded only 1 or 2 colonies on 3 occasions. (As the wards all opened upon a common corridor there was ample opportunity for the occasional contamination of a ward by air currents from outside.) Mrs. White's paper also showed that the streptococci found in the air were usually of the same serological type as that of the patient in the ward; and that the number of streptococci on the plates was much increased by sweeping or bed-making; also that they could be recovered at least 5 days after the patient had left the ward (notwithstanding the fact that the rooms were all very light and faced due south). On one occasion, after sweeping out such a ward (5 days after the patient left), Mrs. White herself developed an acute pharyngitis due to a streptococcus of the same type as that isolated from the patient who had been in the room.

Chiefly owing to the arrival of Prontosil (1936) at this time, our attention and energies were diverted for a while and we did not follow up these observations directly upon the patients' bedding. My assistant, Mr. Maxted, did, however, infect the dust of a dark cupboard and showed that in this the streptococci remained alive for at least 10 weeks. He, too, acquired an acute streptococcal tonsillitis and adenitis in the course of this work, and the strain recovered from his throat was identical with the one he had sprayed into the cupboard. The cocci in this cupboard dust retained their full virulence for the mouse for at least 25 days.

Since that time at least 3 papers have reported puerperal fever outbreaks in which the authors thought it probable that dissemination of the streptococci was by way of the air. The first of these, by R. Cruickshank and Godber¹⁸, dealt with 2 such outbreaks. The evidence of aerial transmis-

sion was suggestive but not, I think, quite conclusive, since it depended in part upon the assumption that there could have been no faults in the labour ward technique. Haemolytic streptococci were recovered from the air of the wards on one occasion. The outbreak reported in 1944 by Kenny and Barber¹⁹ in the obstetric unit of the British Postgraduate Medical School was of particular interest. In spite of exceptionally thorough and prompt investigation, involving the examination of some 350 swabs, the place of origin of the streptococci was not discovered. These organisms were, however, recovered from the dust in 2 situations, namely the office of the Maternity Unit, and the underside of a lavatory seat which had been used by all but 2 of the 7 mothers who subsequently became infected. This lavatory seat was only 2 feet away from a porcelain slab on which the mothers were bathed before delivery. One can only speculate as to the probable source of the streptococci found in these 2 situations. In view of what we have since learned about the dispersal of streptococci on blankets and clothing, my guess would be that the air of the lavatory and bathroom was polluted by streptococci introduced in this way by one of the antepartum women who was either a nasal or, possibly, a genital tract carrier. (It is of interest in this connection to recall the observations of Thomas²⁰, who counted the haemolytic streptococci in the dust obtained from the several rooms of a Scarlet Fever Unit and found that the largest number (38 millions) was present in the dust of the bathroom-plus-lavatory annexe.)

This report of Kenny and Barber, like that of Cruickshank and Godber, calls attention to an important fact which we had not previously recognized, that mothers who remain afebrile during the puerperium may sometimes harbour haemolytic streptococci in the genital tract—they are, in

fact, for the time being, genital tract carriers. Unfortunately, none of these cases seems to have been followed up after they left the hospital to ascertain how long the carrier condition persisted.

The third outbreak, which involved some 14 postpartum cases in a private nursing home, was reported in considerable detail recently by Knox and Marmion²¹. Again the ultimate source of the streptococci was not found, but strains of the serological type infecting the mothers were isolated from the air or dust on 8 occasions, and the facts certainly suggest that the dispersal of the organisms by the air may have played an important part in their transmission to new patients.

Apart from these suggestive epidemiological findings, an impressive body of evidence from non-obstetric sources has accumulated during the war, which warrants 2 far-reaching conclusions, viz. :

- (1) That pollution of the air by patients discharging streptococci or other pathogens occurs much more commonly, and on a far greater scale, than has usually been recognized.
- (2) That bedding and dressings play a large part in this pollution of the air.

I will briefly review some of that evidence. Willits and Hare²², investigating 14 patients with streptococcus-infected surgical wounds (some of whom were also throat carriers) in Toronto, showed that streptococci of identical type to that of the wound could frequently be recovered from the skin of remote parts of the patient's body, from his clothing, or bed-clothes, as well as from the air surrounding him. Their data support the findings of Wright and Cruickshank²³ as to the dispersal of streptococci by bed-making; and show that a similar dispersal might occur from surgical dressings during their removal. Curiously enough, these workers did not pay much

attention to blankets *per se* as a potential source of aerial contamination.

The extensive work of Hamburger and his colleagues²⁴ who investigated the air of wards housing patients with measles, German measles and other respiratory tract infections, led them to the important conclusion "that the greater number of the haemolytic streptococci in the air probably originate in the 'secondary reservoirs', i.e. in the floor-dust and bedclothes, and that relatively few are present as 'droplet nuclei' dispersed directly from the respiratory tract. Their paper includes this important sentence: "Cultures of pyjamas, sheets, pillow-cases and blankets of some of these patients have revealed hundreds or thousands of hemolytic streptococci as soon as 6 hours after the patients have been placed in clean bedlinen."

The importance of blankets as potential reservoirs of infection was also studied by Lemon²⁵, who found no less than 48,000 haemolytic streptococci on one blanket which had been in use on a scarlet-fever patient's bed for 5 days, and 29,000 on a smaller blanket which had been in use for 2 days.

I would like now to show you some visible evidence obtained recently by Dr. Bourdillon and myself in the Burns Unit of the Birmingham Accident Hospital. First I must briefly introduce you to an instrument with which most of you are probably not familiar but which will, I hope, come to form part of the equipment of every large hospital or group of hospitals. This is the 'Slit-Sampler' devised by Bourdillon, Lidwell and Thomas²⁶ for determining the bacterial content of the air. It is essentially a sealed chamber with a narrow slit in its roof through which air is sucked by an electric pump at a definite rate, and made to impinge on the surface of a slowly revolving blood agar plate contained within the chamber (Fig. 1). By this

ingenious instrument we are able to count the number of particles carrying microbes in the air from moment to moment—for example, during the progress of a surgical dressing or an operation.

Such a record of changes taking place in the air during a six minutes' period before and during the dressing of a small burn is shown in Fig. 2. On this occasion bedding was not exposed, so there was no bacterial 'shower' from disturbance of blankets, but the effects of disturbing the bandage and wool are clearly shown. This effect is quite typical of that seen in many similar experiments.

The next series of 'bacteriographs'—as these records might be called—(Fig. 3) shows an extreme example of the bacterial 'scatter' that may occur during the removal of bandages—in this case from a 6-days-old burn of the buttock and thighs of a stout woman. The dressing was slightly moist with exudate (and probably also with urine). Fig. 3 (a) shows the scanty growth of colonies from 40 c. ft. of air before dressings were commenced (1.4 per c. ft.). After the sampling depicted in (a) three small dressings were carried out which raised the bacterial content of the air of the room to between 7 and 14 per c. ft. The result shown in (b) indicates the very heavy contamination of the air which synchronized with removal of the bandages (approximately 154 particles carrying organisms per c. ft.). Most of the colonies are of coliform bacilli and gram-negative cocci (*Diplococcus crassus* type) which were predominant on the patient's burns. The air sample taken half an hour after the dressings were finished (c) and the room left empty shows a complete disappearance of the contaminating organisms and a return to the standard of purity shown in (a).

In Fig. 4 is seen a similar series—before dressing; during removal of bandages from a burn of the shoulders; and again after the

room had been left empty for half an hour. In this case the burns were infected with *Staphylococcus aureus* and that organism was present in large numbers on the air plates.

Even higher bacterial densities have recently been encountered while dressings were being done in a Saline-Bath Room; and on almost every occasion the pathogens found on the burned area, some 4-7 feet from the Slit Sampler, were recovered also from the air. Happily we have recently had so few haemolytic streptococci among our burns that I have not been able to get a good record of their scatter in the air, although we have on occasion found a few colonies, just as with other pathogens.

The remaining photographs illustrate the pollution of the air which results from liberation of fluff from blankets and woollen bedclothes. Fig. 5 (a) shows the growth from a 40 c.ft. sample of quiet air and (b) the air of the same room a few minutes later, when the blanket from a patient's bed was momentarily shaken three times at a distance of 3-4 feet from the Slit Sampler. Fig. 6 records the result of shaking (a) a pyjama jacket fresh from the laundry; (b) the same jacket after it had been worn for 3 hours by a patient with burns of the shoulders, completely covered with the usual dressings and a sterilized crepe bandage; (c) the same jacket after it had been worn for 22 hours. A large proportion of the organisms disseminated in the air from this jacket after contact with the patient and his bedclothes were pathogenic staphylococci.

What bearing has all this—and much more evidence of a similar kind—upon the practice of midwifery and of surgery? It brings home to us, surely, that whenever we take down a dressing in an open ward, or in the operating theatre; whenever even pads are changed in a lying-in ward; whenever beds are made; we are in fact

scattering very large numbers of unseen microbes through the surrounding air. The majority of them are harmless types, chiefly micrococci and diphtheroid bacilli, derived from human skin, or are such 'wild' types as are native to the air and soil, e.g. moulds, actinomyces, etc. But not infrequently, in our hospital work, mixed with these harmless types will be a considerable proportion of human pathogens—*Staphylococcus aureus* very commonly, less commonly haemolytic streptococcus, *pyocyanus*, coliform bacilli, *B. proteus* and perhaps viruses as well. In this connection we do well to remember that about 1 to 2 per cent of all our patients are nasal or heavy throat carriers of haemolytic streptococci; and a much larger number are skin or nose carriers of *Staphylococcus aureus*; so that opportunity must occur very frequently for dispersal of such pathogens in handkerchiefs, clothing, bedding, dressings, etc.

This is a disquieting picture, but we can scarcely shut our eyes to it if we want the maximum of safety in maternity work and in surgery. It becomes still more disquieting when we discover, as I did in Glasgow in 1942, that the standard laundry practice in most of our hospitals does not even attempt the sterilization of blankets and woollen bed-wear. I came upon that knowledge in this way. Finding that something like 80 per cent of the cases in the Burns Unit of the Glasgow Royal Infirmary were becoming infected with haemolytic streptococci within the first few days—many of them on the first day—of their stay in hospital, I began to wonder if some of this infection was being conveyed by the blankets which were put over the patients as soon as they arrived in the ward—often shivering and with no dressing at all over their burns. Cultures from a very small area of 2 blankets (out of 20 examined), fresh from the laundry, yielded haemolytic

streptococci of the same type as that which was infecting all the burns. On inquiries being made into the laundry procedure (which I subsequently learned was quite usual in other hospitals) I found that the dirty blankets and other woollens were treated in a 'tumbler' of soap solution at a temperature of 37–43° C. Higher temperatures, such as would have killed haemolytic streptococci and other ordinary pathogens, had to be avoided, I was told, because they caused the woollens to shrink and to become felted. I shall have more to say upon this question later.

THE CONTROL OF AIR-BORNE INFECTIONS.

If I have succeeded in persuading you that contamination of the air by the dispersal of dried dust, visible and invisible, is a common event, and fraught with danger, the question arises: What can we do about it? You will tell me that all our operating theatres, and many labour wards, are purposely designed to avoid just this danger. True, but is that enough? We take care to prevent permanent lodgment of the dust, but have we done all we might to prevent it coming in—on ward blankets, on woollen bed-wear, on theatre stockings, etc.? And have we not, in many theatres, permitted nurses, students and others to come in with outdoor shoes, bringing contaminated dust both from the hospital wards and from the streets? And have we not often ventilated our operating theatres in quite the wrong way—sucking out vitiated air by a fan at roof level and forgetting that this must be replaced by dust-laden air from the corridor, instead of bringing in clean filtered air under positive pressure from the roof of the hospital?

In the wards, both lying-in and surgical, we have scarcely begun to eliminate dust. Dry sweeping is almost universal, but Van den Ende and his colleagues²⁷ have shown

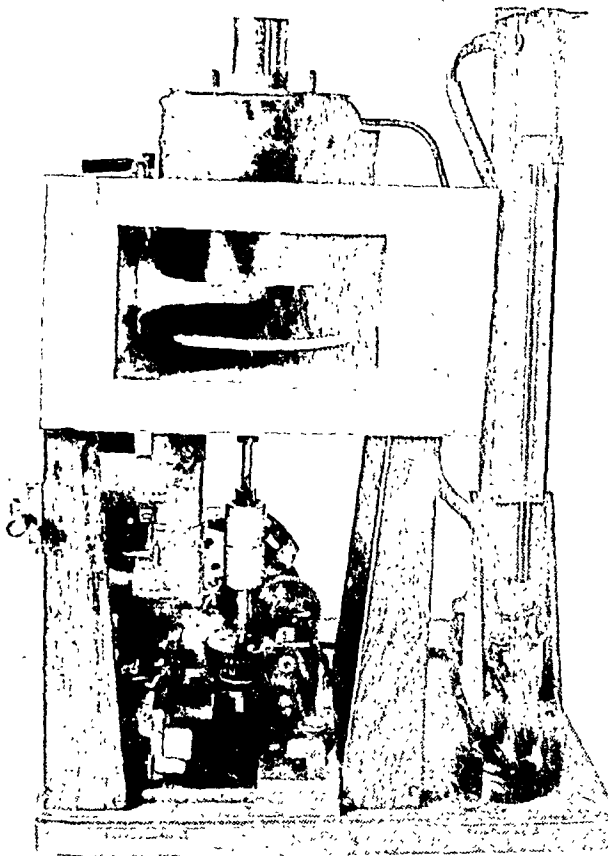


FIG. 1.

The Slit-Sampler (Bourdillon, Lidwell and Thomas)
L.C.

DRESSING SMALL BURN OF KNEE

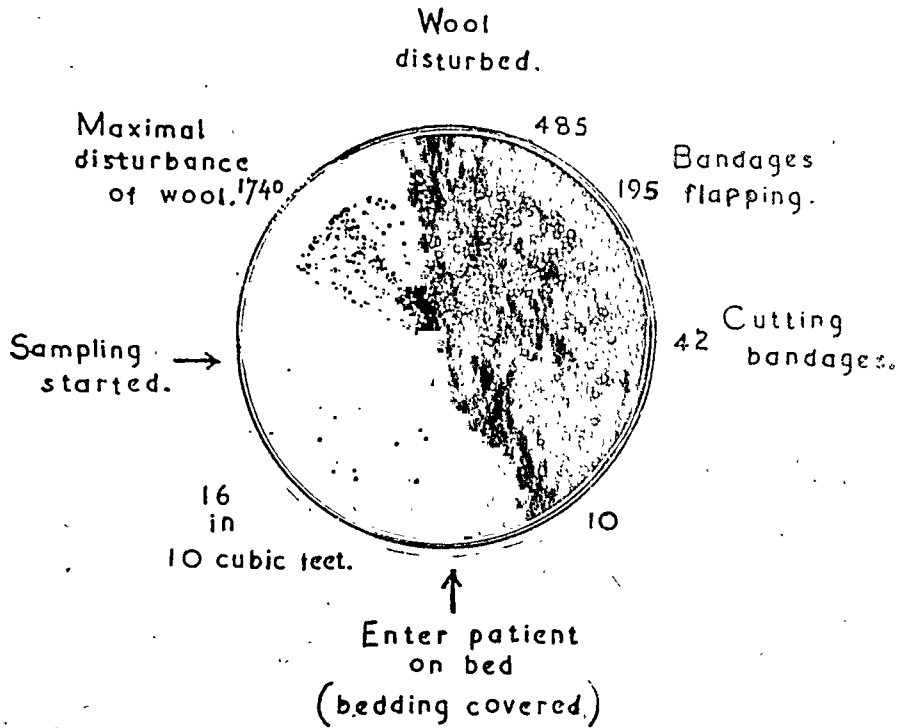


FIG. 2.

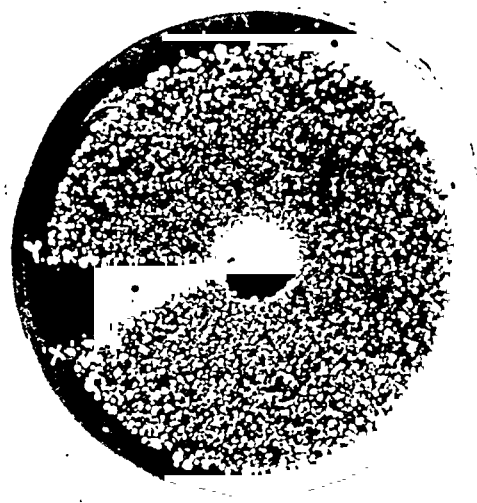
Blood agar plate exposed in Slit-Sampler to 40 cu.ft. of air during a 5½-minute run.

FIG. 3.

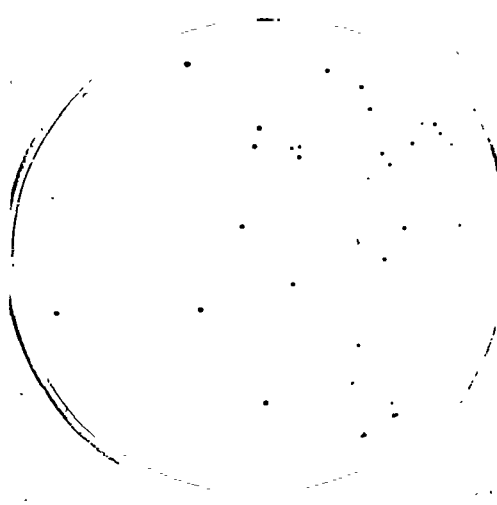
A. Before dressings were commenced.



B. During removal of bandages from burns of buttocks and thighs.



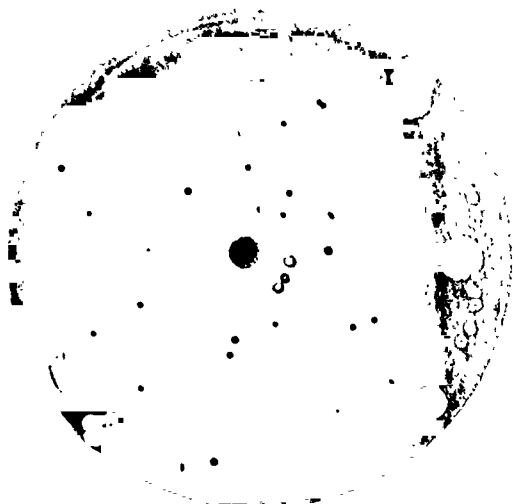
C. Half-an-hour after dressings finished.



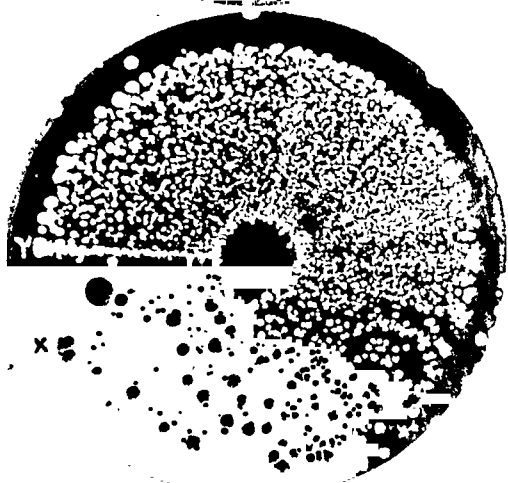
[Sampling started at X and finished at Y.]

FIG. 4.

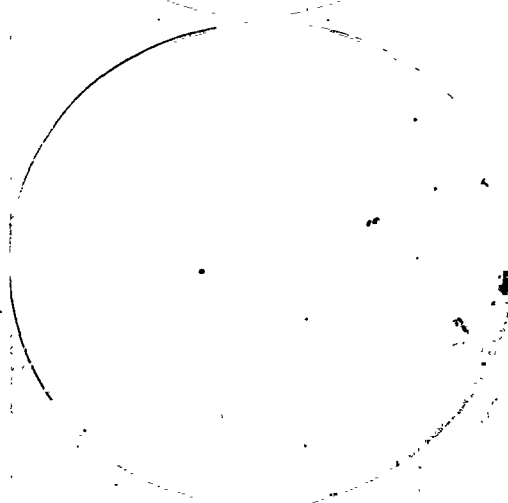
As FIG. 3. Burns of shoulders.



A. Before dressings commenced.



B. During removal of bandages



C. 15 minutes after patient left the room.

[Sampling started at X and finished at Y.]

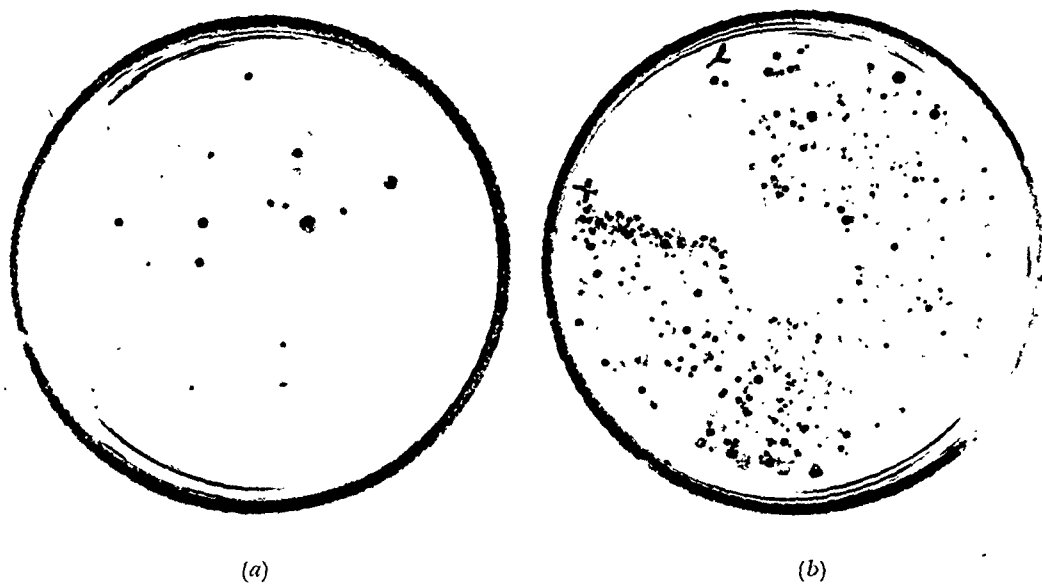


FIG. 5 (as FIGS. 2, 3 and 4).

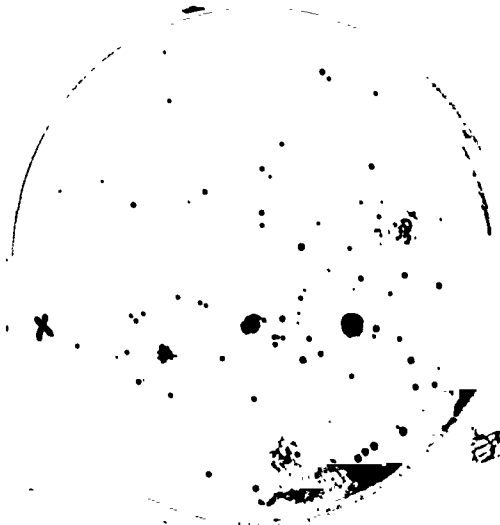
(a) Air of room before shaking blanket from patient's bed (2 cu.ft.).

(b) Air immediately after shaking blanket 3 feet from Slit Sampler (2 cu.ft.).

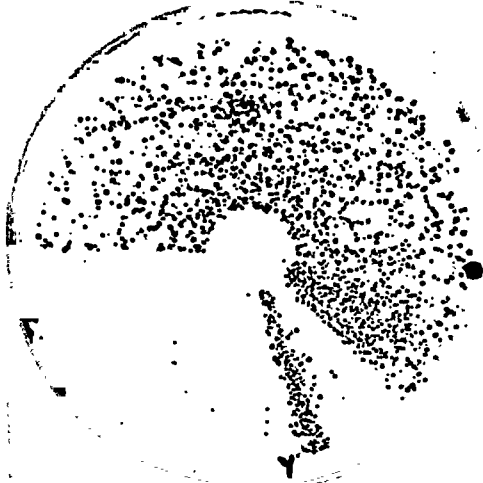
Sampling started at X and finished at Y.

FIG. 6.

Shows organisms liberated from pyjamas.



A. Before being worn.



B. After being worn for 3 hours by patient with burns of shoulders.



C. After being worn by same patient for 22 hours.

[Sampling was started on each plate at X and pyjamas were shaken at Y.]

that, by the simple expedient of oiling the floors once every 2 to 3 weeks, the dust can be matted so that sweeping will not disperse it through the air; and workers in America have confirmed the great value of this simple measure in reducing pollution of the air. It should, I think, be adopted as standard practice throughout our hospitals.

The same workers have shown, too, that by dipping blankets and woollens in a special oil after they have been laundered, and spinning out the excess in a centrifugal machine so that the oil left is not perceptible to ordinary examination, the liberation of fluff can be very greatly reduced. Owing to shortage of laundry staffs it has been difficult to get this done during the war, but in normal times this, too, might well become a routine procedure. Its great value in reducing cross-infections by streptococci was strikingly shown by Joyce Wright, Cruickshank and Gunn²³, in the measles wards of the London County Council Hospitals.

I spoke earlier about blankets not being sterilized. But they can and should be sterilized. Dr. McCartney and Dr. Cruickshank in the L.C.C. service have shown that they can be steam heated without injury if the pressure is kept down to 5 pounds and the time does not exceed 20 minutes. We confirmed this in Glasgow. Such sterilization will not, of course, kill spores, but it will certainly kill the ordinary non-sporing pathogens such as streptococci.

Blankets can be sterilized in another way, namely by subjection to very strong formalin vapour for 24 hours in a sealed chamber. My colleague, R. M. Fry²⁸, has shown that it is necessary to use a fairly large quantity of formalin, or, better, para-formaldehyde—50 g. to 1,000 c. ft. of air—and to make sure that the room is perfectly sealed so that the vapour cannot leak away. In my experience this has not always been successful if the blankets are

heavily infected with pathogens embedded in an organic matrix such as blood or pus, although for more lightly infected bedding it does suffice.

A third method should be feasible, viz. chemical sterilization during the laundering process, if we could substitute one of the newer antiseptic detergents for the soap usually employed without harm to the blankets. This matter awaits investigation. At present the soap used is chosen for its cleansing properties only.

Finally, I would ask you to think about a more fundamental reform which is worthy of serious consideration in the planning of new maternity and surgical hospitals. I mean the conception that we should do all our obstetrics and surgery in bacteriologically clean air. At present we take great care to prevent anything infected touching the exposed tissues during delivery or an operation, but we are apt to forget that the air touches them all the time and frequently carries pathogens in considerable numbers. I would like to tell you briefly how we have tackled this problem in connection with burns.

My experience in Glasgow had shown me that there was little hope of eliminating cross-infection by streptococci by a rigid dressing technique, masking, etc., so long as the burns were dressed in the open wards, obviously exposed to dust. It seemed clear that a better plan would be to dress them in a special dust-free room, if we could avoid the danger of transmitting the organisms liberated from one patient's dressings to the next. At the Birmingham Accident Hospital we have installed a forced ventilation plant to give us such an abundant stream of warm, filtered air that the whole atmosphere of the room is swept clean about once every 5 minutes. That plan appears to have been successful beyond all our hopes.

In the first year of working since the

plant was installed we have carried out more than 1,400 dressings, usually about 6 per morning, and many of them of extensive burns. Cultures have been taken from each wound every time it was dressed and a complete record has been kept of the order in which the cases were dressed. A very careful scrutiny of these data seems to show that in no single instance has either a haemolytic streptococcus or a pyocyaneus been transmitted in this Dressing Room. A few such added infections have occurred, but the circumstances in every case clearly suggest that the infection occurred in the wards between dressings—no doubt from dust—not in the Dressing Room. That seems to me a remarkable achievement, bearing in mind the past history of burns.

This experiment on ventilation by mechanical displacement of polluted air is of considerable interest. The method is free from the disadvantages attached to sterilization by ultra-violet light and by bactericidal vapours, which have been used in America; and would seem to be more effective than these procedures for eliminating dust-borne bacteria. A ventilation plant such as we have employed in Birmingham need not be a very elaborate or expensive affair provided the air is taken in at a sufficiently high level. Even in the middle of Birmingham the air on the hospital roof is remarkably free from human pathogens.

Whichever technical process is adopted there can be little doubt that continuous ventilation with bacteriologically clean air should be regarded as a reasonable requirement for our labour wards, operating theatres and dressing stations: and also, it may be added, for infant nurseries and premature baby wards. The ventilation of lying-in and other wards is a more difficult problem which I am not competent to discuss.

In conclusion might I briefly suggest to you a few features which should be consid-

ered in planning our maternity institutions of the future:

(1) These institutions, if part of a general hospital, should be separate blocks, in order to avoid the possible transmission of infected dust from the surgical or isolation wards by air currents.

(2) There should be a much more generous provision of single-bedded wards than hitherto, in order to allow of the immediate segregation of febrile cases, without waiting for the result of the bacteriological examination. Waiting involves the risk of dissemination of pathogens by bedding, etc.

(3) All wards should be so designed (especially their windows and fireplaces) as to lend themselves readily to sealing with tape for fumigation by formalin or other vapour. This is a point that has not received attention in the past.

(4) Ideally there should be separate quarters for nurses working in the 'clean' wards and in those for febrile cases; but I can see no harm in their mixing when out of uniform. We should remember that the uniform and shoes of medical and nursing staffs must inevitably acquire some contaminated dust from the 'infected' wards. There should be a strict rule about washing of hands before leaving these wards, and throat swabs should be taken before nurses are transferred for duty in 'clean' wards.

(5) Hospital laundries should be equipped for oiling blankets and other woollens and should have separate plants for the washing of bedding from the clean and the infected wards. The soap used in the laundry should be chosen for its bactericidal as well as its cleansing effect.

(6) Provision should be made for the proper ventilation of labour wards, operating theatres and dressing stations with dust-free air.

(7) There should be a 24-hour bacteriological service available in all the larger

maternity institutions, so that swabs can be planted at any hour and a provisional report made without delay. This would mean the provision of a small incubator and the training of at least 2 permanent members of the staff so that they could at least recognize haemolytic streptococci. Their provisional reports must, of course, always be confirmed later by a bacteriologist.

These are the ideas I would leave with you. If you agree that they warrant serious consideration I would add one more that seems to me important. I feel that we need—in some at least of our larger hospitals—a new type of officer whose duty it would be to continually supervise and improve the network of preventive measures we provide. We have been too haphazard and amateurish in the past. Clearly the job is one of applied bacteriology. Such an 'Infection Control Officer' would see to it that the equipment for sterilizing dressings, bedding, bed-pans, etc., is satisfactory, and would carry out periodical tests of its efficiency; he would look into laundry practice; he would organize a service for the supply of sterile syringes with properly sharpened needles; he would advise on the choice of antiseptics and their proper use (a great field for economy). In addition to this and a hundred other matters of daily routine he would advise as to the provision of segregation wards and supervise their fumigation when required; he would be notified automatically of cross-infections occurring anywhere in the hospital and would undertake at once investigations necessary to trace their source; he would ascertain, by periodical tests, that the air supply to theatres, labour wards, etc., is satisfactory, just as, for years past, we have ascertained that water and milk supplies are satisfactory; he would also be responsible for the instruction (with ample practical demonstrations) of students and

nurses in all that pertains to the prevention and control of hospital infections.

There can be little doubt that the appointment of a few such officers in our larger hospitals would quickly raise the standard of preventive measures in all the medical services.

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The Value of Antenatal Radiological Pelvimetry

(A Comparative Survey of the Prediction and Event in 300 Successive Pelvimetric Studies at Queen Charlotte's Maternity Hospital.)

BY

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THE value of any method of investigation in practice is clearly dependent upon its reliability and upon the trust that may be placed in the information afforded by it. The study of foetal-pelvic relationships and their influence on the mode of delivery is a study in complex dynamics: by careful antenatal clinical and radiological examination it should be possible to predict with reasonable accuracy the mechanical disadvantages that may arise in the course of any given labour. The influence of 2 important factors, however, cannot be predicted antenatally: these factors are, firstly, the efficiency of the uterine contraction forces, and, secondly, the part played by soft tissues in certain cases.

This paper is a frank attempt to assess the reliability of prediction of the course of labour from antenatal radiological examination alone. It is an attempt to indicate to obstetricians what reliance they may place upon the inferences drawn from a thorough radiological examination by a radiologist with particular interest in, and experience of, obstetric radiology: in the course of the paper it will be shown what has been learnt from a careful follow-up in the borderline cases of disproportion.

In the last 15 years it has been clear from

published work that an increasing use has been made of radiological pelvimetry by obstetricians to aid them in their decisions as to the wisest mode of conduct of labour. In earlier years there was much scepticism amongst obstetricians as to the value of X-ray examination. This scepticism is now much less widespread though it still exists. The superb work of Caldwell, Moloy and their colleagues has done much to show how useful radiological examination may be in obstetrics. In recent times in this country it is apparent from published work that certain obstetricians (Chassar Moir,¹ Meave Kenny²) place considerable reliance upon X-ray examination, tempered with a dominant clinical judgment. The 2 obstetricians mentioned make their own interpretations from radiographs and their observations are of especial interest because they are, no doubt, directly or indirectly responsible for the conduct of the deliveries. Relatively few obstetricians, however, have made an especial personal study of the scope of X-ray examination, and few have had as intimate an opportunity of assessing its value as Moir and Kenny. We would suggest that the ideal personnel for investigating the problems of disproportion would be a team composed

of an obstetrician interested in the radiological approach and a radiologist interested in obstetrics. Such a team is rarely to be found in practice.

Thus the majority of obstetricians who wish to use radiological methods will have to rely in part on their radiological colleagues for an evaluation of the information that is made available. This paper is intended to show on what grounds clinical judgment should be aided, influenced or amended by radiological findings and the degree of accuracy in prediction that may be achieved.

CLINICAL MATERIAL IN THE SURVEY.

The comparison of the radiological prediction and the eventual mode of delivery is based upon a study of 300 pelvimetric cases (examined in the Radiological Department at Queen Charlotte's Hospital between 1942 and 1945) together with a careful follow-up study of each delivery. The series is successive in that it includes every case delivered in Queen Charlotte's Hospital on whom a pelvimetry had been performed. Only those cases delivered in Queen Charlotte's Hospital have been included. Many other pelvimetric examinations have been made in the Department during this time on women who have been delivered elsewhere: e.g. those evacuated from London for reasons arising from the war, those sent up for a consultant's opinion only, and private patients referred to the Department. This group has not been included in this survey because it was felt that only those cases with full recorded notes should be assessed.

Whilst there has not been any radiological selection of the case material, the clinical selection of cases for reference to the X-ray Department has been highly critical. The references have been made for the most part by experienced obstetric consultants (*vide infra*). At no time has

radiological pelvimetry been used as a mere routine measure at Queen Charlotte's Hospital. It is fair to state that every case referred has presented a distinct antenatal problem, and in each some guidance or assurance was genuinely sought. This implies that the radiological predictions have been made on a series of patients critically selected on clinical grounds—a necessarily severer test of the value of prediction than if a haphazard group of expectant mothers had been referred for examination. The reader may require to know the status of those referring the cases—they fall into two groups: (1) Consultants (60 per cent of the references) either honorary staff surgeons or antenatal officers; (2) Resident obstetric officers (40 per cent of the references) chosen specifically for their interest and experience in obstetrics and who, almost without exception, have completed the examination for Membership of the Royal College of Obstetricians and Gynaecologists shortly after completing their appointments.

It will readily be agreed that the claim that expert clinical selection of cases for pelvimetry has been made is fully justified.

A routine follow-up study has been made each week (as soon as possible after the delivery) from the notes which are kept jointly by the responsible resident medical officer, and the labour ward sister. The standard of record keeping at the hospital is very high. The medical officers are requested to state clearly in their notes the exact indications for any operative intervention. If any point has not been clear from the notes one of us (E.R.W.) has discussed the matter with the officer concerned.

For the purpose of this survey, the correctness of the routinely written radiological predictions (made by E.R.W.) has been assessed by the obstetrician (L.G.P.)



FIG. 1A

W. & P.

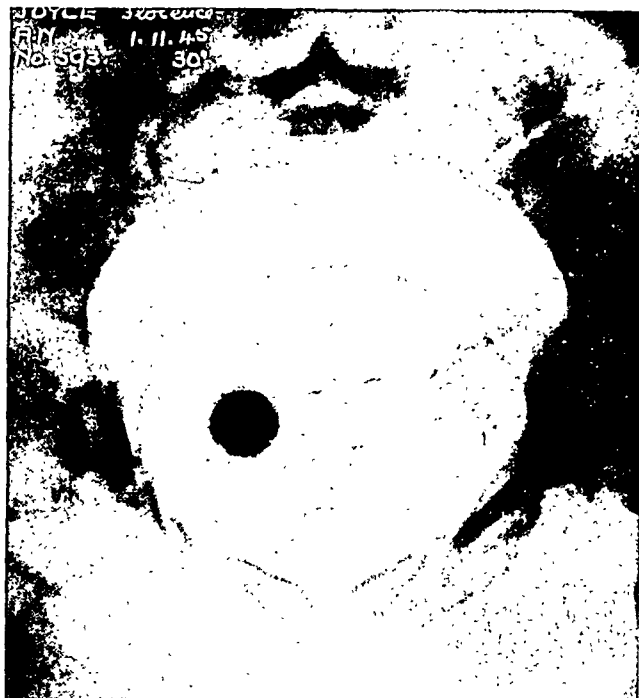


FIG. 1B

W. & P.



FIG. 1c

W. & P.



FIG. 1D

W. & P.

in all instances other than those in which the prediction was "no disproportion, normal delivery" and the event "normal delivery." Any doubtful case has been specifically subjected to the criticism of the obstetrician (L.G.P.).

TECHNIQUE OF RADIOLOGICAL EXAMINATION.

The technique described below has been used routinely and fully in every case in the series whatever the reason for the reference of the patient. Not infrequently a pelvimetric examination is requested but not carried out fully when the reason for reference is "high head, difficult to push in." An erect lateral view is taken first; if the head is seen to be engaged in this position, the radiograph is immediately submitted to the obstetrician who then decides whether a full routine examination is necessary. Those cases in which only a lateral view has been taken are not included in this series.

The technique in use at Queen Charlotte's Hospital has been designed to give the maximum information as to the size and shape of the pelvis. It has been elaborated from a method described by Courtney Gage³ which had been in use at St. Mary's Hospital since 1929. The routine technique has been described fully elsewhere.⁴ Briefly, the projections taken are these (Fig. 1 A to D).

1. Anteroposterior of whole pelvis and lower spine, patient supine (stereoscopic pair may be useful).
2. Supero-inferior of the pelvic inlet. ✓
3. Lateral in erect posture. ✓
4. Subpubic arch projection (a modification of Chassard's projection).

In all cases, a true reduced chart of the pelvic inlet, showing its true size and shape, is made (for method, see references 3 and

4). Further, in any borderline case, a similar reduction chart is made from the lateral projection of the medium plane of the pelvis (Fig. 2a.b).

Foetal head models may then be directly compared against these two-plane charts. In specific cases an approximate chart of the bony outlet, as advocated by Moir,¹ may be made though this is an artificial reconstruction and not a single plane reduction from the false to the true size. It is of considerable value, nevertheless, in studying relative proportions in cases with a restricted outlet (Fig. 2d).

The reconstruction-charting just described may be applied to the foetal head after the 34th week of pregnancy. Two projections of the foetal head are obtained and from these, in approximately half the examinations, specific cephalic diameters may be measured. Approximate cephalometry is relatively easy in most cases: accurate cephalometry is difficult in many cases. It is not so much that the size of the shadow of the foetal head is difficult to correct but rather that a precise diameter is often not projected. In any given case, there are 2 technical problems: firstly, is the measurement of the foetal head accurate? Secondly, can one be certain that specific diameters are available for measurement?

Frankly, accurate cephalometry is far from easy to achieve in many cases: is its achievement really necessary? It should be aimed at because obviously for any given pelvis the ideal disproportion-study can be made only with the foetal head that is to go through it. But one has to realize that a foetal head may undergo appreciable diametric changes owing to moulding, and, more important, that there is no way of anticipating with assurance which diameters of the head will present at different pelvic levels; and that the influence of the soft tissues on the rotation, flexion and extension of the head is a factor of great

importance. We are dubious about the value of painstaking cephalometry and prefer to consider a foetal head as either average, small or large for its maturity. The present attitude is therefore this: when feasible a cephalometry is done and the measurements of what are

- (2) In those cases in which a specific cephalic diameter is shown, this is corrected and the true diameter stated: otherwise an attempt is made to classify the head as average, large or small: the degree of ossification is also assessed.

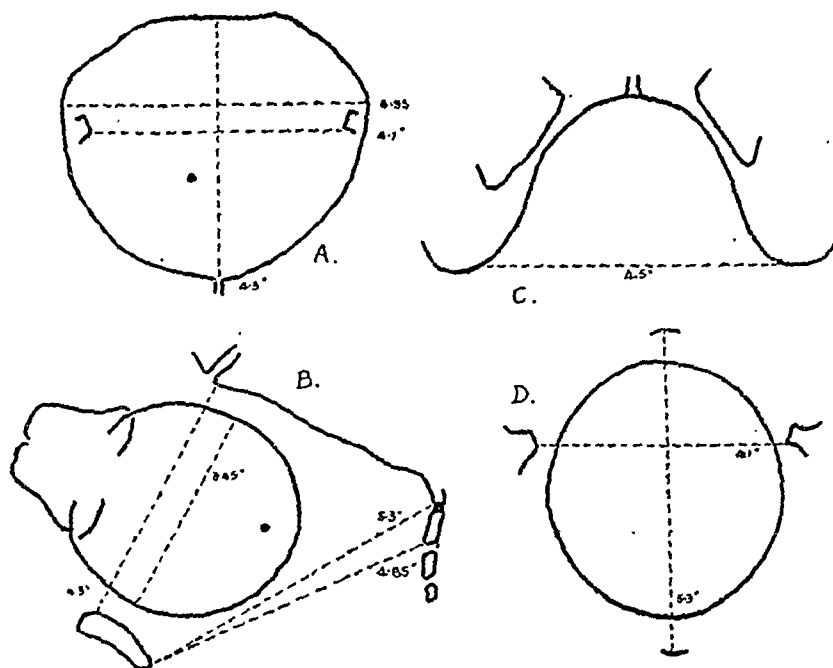


FIG. 2

believed to be specific cephalic diameters are stated: when doubt is felt as to their accuracy, comparison is made against the background of the pelvic reduction charts with models of hypothetical average full-time foetal heads.

THE RADIOLOGICAL REPORT AND PREDICTION.

A special report form is used: on it are printed 3 outline drawings of the pelvis to which the diametric measurements are added (Fig. 3). A full descriptive report is given as follows:

- (1) The lie of the foetus, the presenting part and the degree of engagement (if any).

(This applies to cases examined after the 34th week. Predictions made from pelvimetric examinations before the 34th week have assumed an average full-time foetal head. In any case which has been grouped as C, D or E (see later), the head size should be estimated by a second examination as near term as possible.)

- (3) A description of the pelvis is given on the lines advocated by Caldwell and his colleagues.
- (4) A commentary is written calling attention to significant features, especial consideration being paid to the lower pelvic strait.

- (5) The report closes with a prediction, essentially based on relative proportion or disproportion, of the mode of delivery.

cases. Much was also learned from pelvimetric studies made postnatally on patients who had undergone a difficult or aided delivery. Later, predictions were given

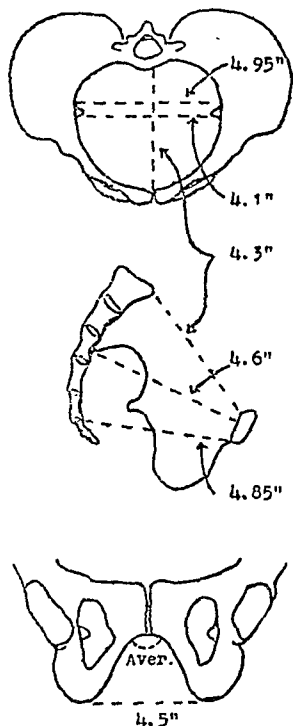
QUEEN CHARLOTTE'S MATERNITY HOSPITAL.

RADIOLOGICAL DEPARTMENT

Name JOYCE, FlorenceClinic or Ward AntenatalObstetric Officer Miss RobinsonDate 1st November 1945X-Ray No. 593.45

MEASUREMENTS

REPORT



FOETUS.

One foetus - Vertex R.O. Lateral.
Head well engaged in erect posture.
Biparietal diameter = 3.45 ins. -
average for 36 - 37 weeks maturity.

PELVIC DESCRIPTION.

The inlet is gynaecoid in character.
The side walls show a minor convergence
and the ischial spines are not
prominent.
The sub-pubic arch is average and is
wholly useful.
The sacro-sciatic notches are average-to-
wide.
The sacrum is somewhat flat superiorly
but slopes well backwards with a
vertical coccyx; sacro-coccygeal
shelf not prominent.

COMMENTS.

A pelvis of average dimensions showing
no unfavourable features in shape. A
good obstetric pelvis.

PREDICTION.

No disproportion - normal delivery.

GROUP A.Radiologist Rohan Williams

FIG. 3

It may be asked by virtue of what experience did one of us (E.R.W.) justify giving a prediction routinely. From 1931 to 1941 he gained his experience in obstetric radiology at St. Mary's Hospital, to which patients from Queen Charlotte's Hospital were referred. As a private exercise, from 1934, predictions were made and follow-up studies undertaken in many

openly in the reports—initially to the tolerant amusement of obstetric colleagues—later with their active encouragement. Late in 1941 he was invited to start the radiological service at the new Queen Charlotte's Hospital, and since November 1941 a prediction has been written in every pelvimetric report. It is believed that much more has been learned from errors in writ-

ten predictions (i.e., an official report) than if the prediction had remained a private mental impression.

THE COMPARATIVE ENQUIRY.

The Prediction.

The written prognosis or predictions have been grouped under five headings, A to E, as shown in Table I.

TABLE I.
Prediction Groups.

Group	Relative proportions	Likely mode of delivery	Qualifications
A	No disproportion	Normal	Without reservations
B	No disproportion	Normal	With minor reservations
C	Minor disproportion	Difficult	Normal feasible
D	Moderate disproportion	Abnormal	Normal most improbable
E	Severe disproportion	Abnormal	Normal impossible

Examples of typical reports in each of 5 groups A to E are given below.

GROUP A. (No disproportion, normal delivery, no reservations.)

Foetus. Left occipito-lateral; head just engaged in erect posture.

Biparietal diameter = 3.8 inches; average for full-time head.

Pelvic description. A gynaecoid inlet (with minimal android tendencies in the fore pelvis) of ample dimensions. The side walls are straight and the ischial spines are not prominent. The subpubic arch is average ("Norman Arch"). The sacro-sciatic notches are of average width and the sacrum is moderately hollowed.

Comments. A good obstetric pelvis; no disproportion; normal delivery anticipated.

GROUP B. (No disproportion; normal delivery with minor reservations.)

Foetus. Right occipito postero-lateral; head not engaged in erect posture.

Biparietal diameter = 3.6 inches; average for 37 to 38 weeks.

Pelvic description. A gynaecoid-flat inlet (true conjugate = 3.8 inches). Side walls, straight to divergent; ischial spines not prominent. The subpubic arch is average. The sacro-sciatic notches are rather narrow; the sacrum is well hollowed (capacious hind pelvis in mid-cavity).

Comments. There may be minor difficulty in engagement but once the brim has been entered, descent should be uneventful.

Prediction. Normal delivery with minor reservation re inlet.

GROUP C. (Minor disproportion; difficult delivery but normal feasible).

Foetus. One foetus, vertex left occipito anterior, not engaging.

Pelvic description. The inlet is almost round, the true conjugate just exceeding the transverse diameter, the latter being well below average (an almost pure transverse contraction). The side walls are straight and the ischial spines not prominent but ischial bispinous diameter = 3.75 inches (less than average). The subpubic arch is average (Norman arch). The sacrum is well hollowed and the sacro-sciatic notches are average-to-wide.

Comments. Probable that engagement and descent will be as direct occipito anterior or occipito posterior. Some arrest on ischial spines likely even with optimal flexion: forceps application will not be easy.

Prediction. Minor outlet disproportion; normal delivery feasible but low arrest anticipated.

GROUP D. (Moderate disproportion; abnormal delivery, normal most improbable).

Foetus. One foetus, breech left sacro anterior, legs extended.

Pelvic description. Bilateral coxa valga.

An android inlet with a markedly narrow forepelvis. Side walls moderately convergent; the subpubic arch is distinctly narrow (Gothic arch), its upper half or two-thirds being useless obstetrically. The anterior-posterior mid-plane and outlet diameters are average. The ischial bispinous and intertuberous diameters are less than average (3.8 inches and 4.05 inches respectively).

Comments. (As for vertex delivery.) To an average full-time head, no difficulty in initial engagement and early descent likely but the narrow forepelvis, narrow subpubic arch and the small transverse lower strait diameters make some mid-plane or outlet arrest certain. Not an absolute outlet disproportion but aid by the forceps will surely be required and will be difficult to apply.

Prediction. Moderate outlet disproportion; android pelvis.

GROUP E. (Severe disproportion; abnormal delivery, normal impossible).

Foetus. One foetus, vertex left occipito lateral; head above brim.

Suboccipito-bregmatic diameter = 4.0 inches; and head well ossified, i.e., large baby or post-mature.

Pelvic description. A very small gynaecoid inlet: true conjugate = 3.3 inches; transverse = 4.1 inches. Anterior-posterior diameters in all planes much below average.

Comments. Severe disproportion to even an average head: this head is large and well ossified: engagement improbable and lower capacities very poor.

Prediction. Absolute disproportion at all planes.

THE ASSESSMENT.

(With explanatory notes for Table II.)

As previously stated, the assessment of the accuracy of the prediction has been made independently by the obstetrician (L.G.P.). In most instances the assessment has been easily made and the prediction regarded as either correct or incorrect; it is essentially made on the

criterion of manifest disproportion (or lack of manifest disproportion) during delivery. It is not based so much on the statement made in Column 3 of Table I ("likely mode of delivery") but rather based on the statement in Column 2 ("relative proportions").

It will readily be appreciated that a Group A prediction of "no disproportion—normal delivery" may be followed by a delivery in which forceps were applied for reasons unconnected with disproportion and the delivery completed without difficulty, e.g. as in the forceps applied for primary uterine inertia or low forceps in a case of cardiac disease. Such a case is not placed in the "correct" column of Table II, but is shown in the column headed "forceps aided—no disproportion" and is finally shown in the "substantially correct" column.

It would clearly be wrong to regard a prediction of "normal delivery" as frankly "correct" when the aid of the forceps was required; but it would also be wrong to regard a prediction of "no disproportion" as frankly "incorrect" in a forceps-aided delivery when no disproportion had been encountered.

A case prediction is regarded as "substantially correct" when delivery was forceps-aided (and easily accomplished) for reasons which are unpredictable from radiological examination.

Predictions which are "Not Assessable."

In Table II is shown a column marked "not assessable". The entries in this column increase in Groups C, D and E, and become maximal in Group E. Almost all of these cases are those in which Caesarean section was performed. A Caesarean section is no test of a prediction of disproportion. For the purpose of this paper, it would have been attractive to have assumed that, because a clinical decision

that a Caesarean section was absolutely necessary, it was therefore justifiable to assume that a radiological prediction of absolute disproportion was correct. This has not been done. Cases delivered by Caesarean section have provided no test of the prediction and are therefore "not assessable." There is no reasonable doubt that in almost all the cases placed in Group E the prediction would have been proved correct.

Percentage Figures.

In Table II the percentage figures are based on the total assessable number, i.e. the absolute total less the "not assessable" numbers.

COMMENTS ON GROUP STATISTICS.

GROUP A.

Total cases, 186. Not assessable, 11. Total assessable, 175.

Correct, 159. Forceps aid, no disproportion, 15. Incorrect, 1.

Substantially correct, 174.

GROUP B.

Total cases, 38. Not assessable, 7. Total assessable, 31.

Correct, 27. Forceps aid, no disproportion, 3. Incorrect, 1.

Substantially correct, 30.

General Observations—Groups A and B.

Of 206 assessable cases in these 2 groups (No disproportion—normal delivery likely)

TABLE II.
Radiological Prediction Groups and Follow-up Assessments.

Prediction groups	A	B	C	D	E	Total all groups
Total cases	186	38	30	25	21	300
Not assessable	11	7	6	8	15	47
Correct	159	27	11	9	4	210
Forceps aided no disproportion ...	15	3	—	—	—	18
Incorrect	1	1	13	8	2	25
Substantially correct	174	30	11	9	4	228
Total assessable	175	31	24	17	6	253
	%	%				%
Correct	90.86	87.10				83.0
Forceps aided no disproportion	8.57	9.68				7.11
Incorrect	0.57	3.22				9.89
Substantially correct	99.43	96.78				90.11

Percentage figures are not worked out for the individual groups C, D and E, because the total numbers in each of these groups are too small in relation to the whole survey to bear legitimate expression in percentage form.

188 had normal deliveries: 18 cases had forceps-aided deliveries for reasons which could not be predicted and in which there was no evidence of disproportion during the labours. There were 2 faulty predictions, 1 in Group A, 1 in Group B.

Thus of 206 cases, 204 had deliveries without any sign of disproportion. It would therefore appear that, in the Queen Charlotte's Hospital radiological service, whatever the reason for the reference of a patient, if a normal prediction is given it may be accepted with high confidence that normal delivery will occur. The placing of a case in Group A or Group B will justifiably give the obstetrician full assurance that normal delivery is most probable: it will be appreciated that abnormal delivery enforced for reasons other than disproportion cannot be anticipated by radiological but by clinical means.

We feel that the reliability of the prediction of normal delivery alone gives full justification for the use of antenatal radiological investigation. The reader may be reminded that all the patients in this survey were critically selected on clinical grounds.

GROUP C. (Minor disproportion. Difficult delivery).

Total cases, 30. Not assessable, 6. Total assessable, 24.

Correct, 11. Forceps aid, no disproportion, 0.

Incorrect, 13.

Substantially correct, 11.

This is a borderline group and, as might be expected, shows the greatest number of incorrect predictions. The fault has clearly been a trend to undue pessimism. In all of the 13 "incorrect" cases, a normal unaided delivery took place without signs of disproportion.

It is of interest that the average birth-weight in the "correct" cases (those in which there was evidence of some disproportion during labour) was 8 pounds, and that the average birth-weight in the "incorrect" cases was 7 pounds 3 ounces.

Has this tendency to undue pessimism been a serious error? We feel that it has not, because at least a sense of awareness for potential dystocia will be fostered in the mind of the responsible clinician. In

this Group C there are examples of cases with identical pelvic and cephalic measurements, some showing dystocia, others having easy labours.

In some cases thought to show minor disproportion radiologically, it is clear that with adequate forces and easy moulding, no sign of disproportion has been manifest during labour. With weak expulsive forces, these cases of anticipated "minor disproportion" might have become examples of moderate or even major disproportion clinically.

It is surely the duty of the radiologist to state that minor disproportion is potentially present even though it may not become manifest during labour.

The week-by-week follow-up of cases has certainly helped one of us (E.R.W.) to realize that some features initially regarded as unfavourable need not have been looked upon as necessarily significant. However, it has only been during the work on this survey that the full realization has matured, so that in future work a less pessimistic view will be taken of certain features in the lower pelvic straits. One of us (E.R.W.) has felt strongly that radiologists have an especial responsibility concerning outlet contraction, and in his anxiety not to overlook the significance of minor degrees of outlet contraction undue importance has been given to the sub-average outlet.

The following conclusions concerning the lower pelvic strait have been reached during this survey:

(a) The pubosacral or anterior posterior outlet diameter may be as small as 3.75 inches, even with a narrow subpubic arch, without necessarily causing arrest of an average full-time foetal head.

(b) The ischial bispinous diameter may be as small as 3.6 inches, even with a narrow subpubic arch, without necessarily causing arrest of an average full-time foetal head.

(c) The combination of a narrow sub-pubic arch, an ischial bispinous diameter of less than 3.8 inches and a pubosacral diameter of less than 4 inches (the lower strait of the funnel pelvis) carries a serious significance.

In Group C, of 25 assessable cases, 22 had either a normal delivery (15) or forceps (7), 2 cases had Caesarean section as an outcome of trial labour, and 1 had "failed forceps and craniotomy." Thus 22 of the 25 cases were not associated with serious danger to the mother. In further practice in this group the majority would be satisfactorily treated as in-patients in a hospital under the care of an obstetric consultant, and a minority might be recommended for trial labour.

GROUP D. (Moderate disproportion; abnormal delivery; normal most improbable).

Total cases, 25. Not assessable, 8. Total assessable, 17.

Correct, 9. Forceps aid, no disproportion, 0.

Incorrect, 8.

Substantially correct, 9.

Of the 8 faulty predictions, the bad prognosis in 7 cases was based on outlet considerations and the remarks made above in Group C also apply here. The one faulty prediction concerned with the inlet was given in a case with a true conjugate of 3.45 inches, a child of 6 pounds 2 ounces being delivered without difficulty.

Of the "correct" cases, 2 had Caesarean section enforced after unsuccessful trial of labour, 6 had forceps for mid-pelvic or low arrest and 1 had a difficult but unaided delivery after induction at the 35th week.

Of the 8 "incorrect" cases, all had normal unaided deliveries, 2 showing unusually strong pains and the average birth-weight was 6 pounds 11 ounces, as against 7 pounds 10 ounces in the "correct" series.

In Group D of the 17 assessable cases, 15 had forceps or normal deliveries unassociated with serious danger to the mother. In future practice, cases placed in this group will be those in which trial of labour would usually be recommended.

GROUP E. (Severe disproportion; abnormal delivery; normal impossible).

Total cases, 21. Not assessable, 15. Total assessable, 6.

Correct, 4. Forceps aid, no disproportion, 0. Substantially correct, 4.

In the majority of cases here with severe or absolute disproportion, elective Caesarean section has been performed. Whilst in the majority the grave disproportion has been recognized clinically, there is evidence that the degree of the severity has not been appreciated in some until the radiological study has been made. In some cases, the decision to perform Caesarean section has resulted directly from the radiological report. We would draw especial attention to the type of case in which clinical examination shows a minor-to-moderate inlet disproportion but in which X-ray examination also shows severe lower strait disproportion. This type of case is fortunately rarely seen but if the condition is unsuspected its mismanagement may well lead to a major obstetric tragedy.

Of the 4 cases assessed as "correct", 2 had enforced Caesarean section after unsuccessful trial of labour, 1 had a Caesarean section with an impaction of the head at the brim for a 60-hour labour, the birth-weight being 7 pounds 7 ounces. In the 4th case there was a very difficult forceps delivery of a baby weighing 5 pounds 5 ounces in fixed low arrest.

Of the 2 cases assessed as "incorrect", 1 had a normal delivery of a 4 pounds 3 ounces baby at the 34th week. The other had an uneventful normal delivery of a 6 pounds 8 ounces baby. The prediction

here can only be described as a mental aberration and if re-examined the cases would be put in Group C.

In future practice the majority of cases placed in Group E might well have elective Caesarean section or, with the minority, a trial of labour.

OBSERVATIONS ON THE CAESAREAN SECTIONS, FORCEPS DELIVERIES AND TRIAL LABOURS IN THE SURVEY.

An analysis of the special forms of clinical conduct of cases in terms of prediction groups is shown in Table III.

TABLE III.

Analysis of Caesarean Sections, Forceps Deliveries and Trial Labours in Terms of Prediction Groups.

Clinical conduct	Prediction group	Total	Not assessable	Correct	Forceps aided no disproportion	Incorrect
Caesarean section (49 cases)	A	10	10	—	—	—
	B	6	6	—	—	—
	C	6	4	2	—	—
	D	9	7	2	—	—
	E	18	15	3	—	—
Forceps delivery (39 cases)	A	17	1	—	15	1
	B	7	1	2	3	1
	C	7	1	6	—	—
	D	7	1	6	—	—
	E	1	—	1	—	—
Trial labour (50 cases)	A	22	1	20	1	—
	B	7	—	7	—	—
	C	9	—	6	—	3
	D	9	—	6	—	3
	E	3	—	3	—	—

The Caesarean Section Cases.

In the series of 300 cases, 49 patients were delivered by Caesarean section. In 42 of these cases, the prediction could not be tested (not assessable). There was a "correct" prediction in the remaining 7 cases. In 1 of these, which was not booked as a trial labour, Caesarean section was

performed because of total inlet arrest (this had been placed in Group E). In the other 6 cases (2 in each Groups C, D and E) under trial labour conditions, Caesarean section was the enforced outcome because of a failure of spontaneous delivery.

Of the 49 cases, 10 had had previous Caesarean section (A, 3; B, 2; C, 2; D, 2; E, 1) and no doubt, at least in the A and B cases, the obstetrician was influenced in his decision to operate by the existence of a scar in the uterus, although the radiological evidence was such that normal delivery could have been expected.

The indications for Caesarean section in the 49 cases are set out below, under their respective groups, in Table IV.

Cases with Previous Caesarean Sections but no Repetition.

Whilst discussing the Caesarean section cases it is of interest to note that in

the series there were 10 patients on whom Caesarean section had been previously performed for reported disproportion, but who were not booked for repeat Caesarean section: 9 of these cases were placed in Group A, and 1 in Group C. The latter case showed a low arrest and had a simple forceps delivery of an 8 pounds 1 ounce baby. Of the 9 Group A cases, 6 had uneventful deliveries, the birth weights being 8.3, 7.14, 6.1, 6.9, 7.2 and 8.6; the other 3 cases showed uterine inertia and were delivered by forceps without difficulty of infants weighing 7.12, 8.3 and 8.10.

disproportion (7 for persistent occipito-posterior, 2 "low" forceps in heart cases, 4 for primary uterine inertia, 2 for foetal distress, 1 for maternal distress). In 3 of the cases previous Caesarean sections had been performed, the forceps being applied in each for uterine inertia. The remaining case, one of deep transverse arrest, was assessed as an "incorrect" prediction.

In Group B there were 7 cases: 1 was regarded as "not assessable" (forceps applied for persistent occipito-posterior). In 3 cases forceps were applied for reasons other than disproportion (2 with prolonged

TABLE IV.
Indications for Caesarean Section Under Prediction Groups.

Indication	Case numbers in prediction groups					
	A	B	C	D	E	Total
Previous Caesarean	3	2	2	2	1	10
Disproportion in primigravida	-	-	-	2	13	15
Disproportion with history of previous difficult delivery	-	-	-	3	2	5
Failed trial labour	-	-	2	2	2	6
Elderly primigravida	4	-	-	-	-	4
Previous stillbirth after difficult delivery	-	1	2	-	-	3
Mitral stenosis	1	1	-	-	-	2
Placenta praevia	1	-	-	-	-	1
Miscellaneous	1	2	-	-	-	3
Group totals	10	6	6	9	18	49

The Forceps Cases.

A review of the forceps cases is of especial interest in relation to the forecast of difficulty at the lower pelvic levels—a difficulty by no means easy to anticipate clinically before the onset of labour.

There were 39 forceps deliveries in the series of 300 cases (Table V). In Group A there were 17 cases. In 16 of these the forceps were applied for reasons other than

second stage and persistent occipito-posterior, 1 with Bonney forceps in a breech delivery). In 2 cases with deep transverse arrest the prediction was regarded as "correct" in view of the clear reservations made in the radiological report. One case was regarded as "incorrect."

Thus in Groups A and B, of the 24 forceps cases, 2 were "not assessable", 2 were "incorrect" predictions and in 20 the

In Groups C and D there were 18 cases, 12 with "correct" predictions and 6 with "incorrect" predictions because normal delivery occurred without difficulty.

In Group E there were 3 cases, all with "correct" predictions: 2 of these had enforced Caesarean section and the third ended in a very difficult forceps delivery of a 5 pounds 5 ounces baby.

The Stillbirths.

In our survey there were 8 stillbirths, disposed in the prediction groups as follows: A, 4; B, 2; C, 1; D, 1; E, 0. In Group A, 2 were assessed as "correct" and 2 as "forceps-aid, no disproportion". The 4 cases in the other groups were assessed as "correct," of which 3 had forceps deliveries.

Thus, in 300 deliveries, there were 8 stillbirths, in 5 of which forceps were applied, one ending with craniotomy.

There was 1 maternal death, from acute eclampsia, in a Group B case with forceps application and stillbirth.

A NOTE ON THE PELVIC TYPES IN THE PERSISTENT OCCIPITO-POSTERIOR CASES REQUIRING FORCEPS DELIVERIES.

Fourteen cases were delivered by forceps because of a persistent occipito-posterior position. The form of the inlet in these cases was:

Gynaecoid 6, android 2, android-pithecoïd 1, pithecoïd-android 2, pithecoïd 3.

If the shape of the hind pelvis at the inlet plane alone is considered, it is found that the character of this pelvic zone was gynaecoid in 6 cases, android in 3 cases and pithecoïd in 5 cases.

This brief note serves to emphasize the significance of pithecoïd and android characters in promoting occipito-posterior positions. It is of interest to note that in only 1 of these 15 cases was there a pos-

terior position of the occiput before the onset of labour.

A NOTE ON THE PROBLEM OF THE HIGH HEAD.

One of the commonest indications for pelvimetric examination is that "the head is high" or that "the head will not push in easily," the obstetrician being clearly suspicious of some inlet disproportion. From 1942 at Queen Charlotte's Hospital the lateral radiograph has been taken routinely with the patient standing and it is seen from such erect radiographs that in a large proportion of cases referred for "high head" that the head is, in fact, engaged. It is clear that examination in the erect posture often will show that no "high head" problem exists. It is now our practice, when the request form states that a "high head" is the indication for reference of the patient, firstly to take a lateral erect film only. If this shows the head to be engaging or engaged, the film is submitted to the obstetrician who is asked to decide whether a complete pelvimetric examination is necessary. It should be stressed that only cases upon which a complete examination has been made are included in this survey.

Surely an important elaboration of routine antenatal palpation is indicated by these findings. If the head is found to be high or difficult to push into the brim with the patient supine or sitting, then that patient should be examined standing. It is suggested that many a "high head" will then be found to have engaged, and that no real problem remains in such cases.

CONCLUSION.

A brief review of the overall figures in the survey will serve to conclude this paper.

(1) In the series of 222 cases delivered without any manifestation of disproportion-

tion, 200 cases (90 per cent) were predicted as likely to have delivery without disproportion.

(2) Of 54 cases having abnormal deliveries due to disproportion, 51 (94.4 per cent) were predicted as likely to have abnormal or difficult deliveries because of disproportion.

(3) Of the whole survey of 300 suspect cases referred by expert clinicians, the prediction was wholly "correct" in 83 per cent of the 253 assessable cases and "substantially correct" in 90.11 per cent; the difference between "wholly correct" and "substantially correct" being explained by the inclusion in the "substantially correct" figures of those cases with forceps-aided deliveries but without signs of disproportion during labour.

These figures may be regarded as a measure of the reliability of information which was obtained by radiological pelvimetry at Queen Charlotte's Hospital in a group of cases which had been selected mostly by experienced obstetricians because they presented some clinical antenatal problem—a critically selected group. It is suggested that with due interest on the part of the radiologist the prediction or prognosis of the course of delivery in terms of relative foetal-pelvic proportions, may reach a high degree of reliability, therefore it may be inferred that the examination and the opinion based upon it, may be of very great value.

In our series those predictions which have been proved to be erroneous have, almost without exception, been unduly pessimistic. Such errors have not once led to obstetric tragedy but rather have ensured that added watchfulness has been maintained in patients whose pelves could not be regarded as functionally ideal in shape or in size, qualitatively or quantitatively for childbearing.

We sincerely hope that this paper will

give those obstetricians who are interested in the radiological study of foetal-pelvic relationships a clearer concept of the reliability of the method. Further, we hope that it will stimulate those radiologists who have not evinced any especial interest in obstetric radiology to prove to their obstetric colleagues, and to themselves, the considerable value of the information that may be gained.

Whilst radiological examination and opinion must essentially remain in a secondary place to clinical examination and opinion, we feel that antenatal X-ray studies should play an important role in helping obstetricians towards the achievement of an increasing accuracy in the antenatal assessment of the likely course of labour, and to aid them in their choice of the best method of delivery in borderline or difficult cases.

We trust that this survey will help towards this goal.

ACKNOWLEDGMENTS.

We wish to express our thanks to the Resident Obstetric Officers and the Labour Ward Sisters at Queen Charlotte's Hospital from 1942-45 for maintaining a high standard of record-keeping and for their general co-operation, and to acknowledge our indebtedness to Miss A. E. Madden, M.S.R., the Radiographer at Queen Charlotte's, for her consistently superb technical work upon which the whole of this study is based.

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Combined Anterior Pituitary Necrosis and Bilateral Cortical Necrosis of the Kidneys, Following Concealed Accidental Haemorrhage.*

BY

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AND

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WE think that the following case of concealed accidental haemorrhage complicated by both pituitary and renal necrosis, the first to be described in this country, is worth recording. Analysis of the findings suggests various points which may throw some light on the mechanism of production of these complications.

CASE REPORT.

Mrs. E. C., aged 31, 2-para; was admitted to this hospital on August 27th, 1945, complaining of severe constant abdominal pain of 5 hours duration. Her past and family history were not significant. In 1937 she had had a full time normal delivery. In 1941 she had had a 7-months' premature still-birth, attributed to the cord being round the child's neck.

History of present pregnancy. Last normal menstrual period, January 20th, 1945. Expected date of delivery October 27th, 1945. She booked at her local clinic on June 26th, 1945, and attended again on July 25th. The urine showed no abnormality on these 2 visits, and the blood-pressure readings were 100/70 and 100/60 respectively. The Wassermann and Kahn reactions were negative. Evidently she was not a co-operative patient since she did not take vitamins and iron as advised.

Since the latter attendance she had had occasional frontal headaches without visual disturbances. Appetite and sleep were normal, but there had been some oedema of the feet for the 3 days prior to admission.

She was watching cricket on the afternoon of the 26th August, and on returning home felt a desire to micturate, went to the toilet and passed a small quantity of urine. Then it was, at 7.15 p.m., that she began to have severe, constant, abdominal pain. She felt "her tummy turn, tighten, and fill up." She fainted and was admitted to this hospital 5 hours later; having vomited several times, but having had no bleeding or shoulder pain.

On admission the patient was found to be very cold and shocked with marked pallor, oedema of the legs two-thirds of the way up to the knees and also of the lower abdominal wall; no icterus. The pulse was 120, of fair volume; blood-pressure, 150/80. Abdomen: Fundus, size of 34 weeks' gestation (31 weeks by dates), very tense and tender and foetal parts not palpable; foetal heart not heard. Fundi and discs normal. Vaginal inspection revealed very slight bleeding. A diagnosis of concealed accidental haemorrhage was made, and the patient immediately treated for shock on the usual lines of heat, blocks to the foot of the bed, injection of morphia, gr. $\frac{1}{4}$, and, after blood had been taken for a haemoglobin (5 g. per cent) and blood urea (57 mg. per cent) estimation, she was transfused with 2 pints of Group O₄ blood; there being no rhesus negative blood available at the time.

* Read at the 70th annual meeting of the Pathological Society of Great Britain and Ireland, Westminster Hospital Medical School, January 4th, 1946.

Progress. While setting up the transfusion the membranes bulged at the perineum; these were artificially ruptured and non-blood-stained liquor escaped. Shortly afterwards a fresh stillborn infant with placenta and membranes were delivered together.

Twenty-six ounces of old and fresh clot and torn placental cotyledons were then expressed, and the patient was given an intramuscular injection of ergometrine 0.5 mg. There was very slight loss afterwards. The placenta was grossly irregular and indented throughout almost half its area, being 9 ounces in weight. Immediately after delivery a catheter specimen of urine, total $\frac{1}{2}$ ounce, revealed 750 mg. albumin per cent.

Thereafter the patient was nursed in a darkened quiet room. She vomited on and off but managed to retain water. During the next night she passed very small quantities of urine on 2 occasions. On the morning of the 28th she was still oedematous, and also, now, were her face and eyelids. There was severe frontal headache, and she was still vomiting. The pulse was 92 per minute, blood-pressure 130/80, blood urea 106 mg. per cent. During the day a further 1 ounce of urine was passed, but as there appeared to be almost complete suppression of urine, she was given 1 litre of isotonic sodium lactate intravenously, in an attempt to bring about diuresis. This was followed by 1 litre of 5 per cent glucose saline at a slow drip.

Next morning, August 29th, only a few drops of urine were obtained by catheter, and there was definite bilateral renal tenderness. For the next 2 days her general condition remained unaltered, although by the graphs (Fig. 1) it will be seen that her output of urine was still negligible, and the blood urea and serum potassium were rising. On the morning of August 31st she complained of indigestion and bilateral renal pain. The tongue was moist and slightly coated, there was no alteration in the oedema, and the fundi and discs were normal. By the evening she was rather drowsy and the respirations somewhat acidotic, and she was not drinking well. She suddenly collapsed and died on the morning of September 1st, the 7th day of her illness.

At no time were measures required for the treatment of symptoms of engorged breasts.

Although the intake of fluid had been satisfactory until the last 18 hours, her total output of

urine from the onset of abdominal pain had been approximately $4\frac{1}{2}$ ounces in $5\frac{1}{2}$ days.

The postmortem blood findings were: blood urea, 216 mg. per cent; serum potassium, 32.8 mg. per cent; plasma chlorides, 505 mg. per cent. In addition her blood group was found to be Az Rh negative, with no anti-Rh agglutinins in her serum. The husband was group O₄ Rh positive.

POSTMORTEM FINDINGS.

The postmortem examination was made 3 hours after death. The abdomen contained 150 c.cm. clear fluid, the right pleural space 350 c.cm. and the left space 150 c.cm. clear effusion. The tissues in general were oedematous.

Genito-urinary system. The right kidney weighed 210 g., the left 240 g. Perinephric fat was abundant. The capsules stripped easily revealing a smooth subcapsular surface mottled by alternating small haemorrhagic and intensely pale zones (Fig. 2). The cut surfaces showed a striking widespread anaemic infarction limited to the cortex and columns of Bertini (Fig. 2). There were bands 1 to 7 cm. long, wedges and small irregular areas a few mm. across of pinkish-yellow, firm, coagulative necrosis, bordered by a fine wavy margin of reactive hyperaemia about 1 mm. thick. These hyperaemic borders were both subcapsular and in the cortico-medullary demarcation line. Scattered between the infarcts were a few streaks of surviving cortex. The medulla was congested. All visible branches of the renal arteries and veins were free from thrombus. The renal pelves were normal, the left ureter normal, the right ureter slightly dilated. The bladder was markedly contracted, its mucosa oedematous, the ureteric orifices patent.

The uterus was enlarged and thick walled (3 to 4 cm. in its thickest portion) and showed 2 large crops of subperitoneal petechiae lying round the origin of each Fallopian tube and extending on to the Fallopian tubes and round ligaments. The cut surface showed extension of the petechiae into the superficial myometrium. Many venous sinusoids in the uterine wall were thrombosed. The placental site appeared healthy. There was a small atrophic corpus luteum of pregnancy in the left ovary. Neither ovary was engorged. The right ovarian vein was enormously distended by thrombus (maximum diameter 3×2.5 cm.) from its origin up to its entry into the inferior vena cava,

into the lumen of which clot protruded. But there was no main caval thrombosis. The proximal 8 cm. of the left ovarian vein was also thrombosed, but not distended.

was enlarged, unusually pale (rendering the pattern obscure) and showed scattered dilated subcapsular veins. The gallbladder contained about 20 faceted mixed stones, though its mucosa and duct

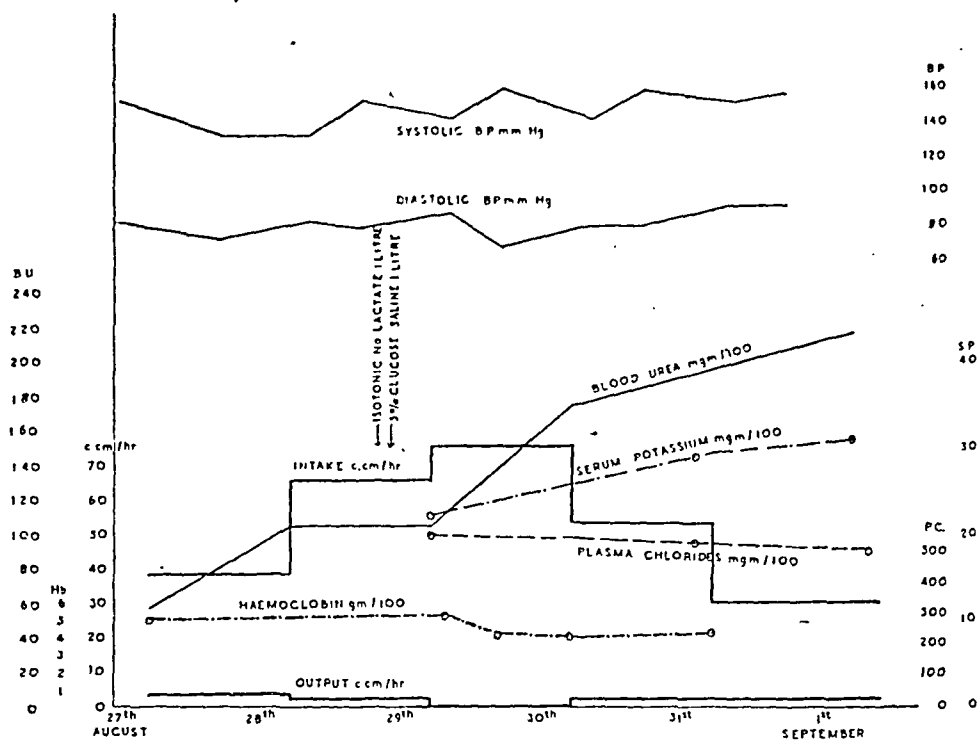


FIG. 1

CHART SHOWING CLINICAL AND BIOCHEMICAL FINDINGS.

Note from above down: 1. Blood pressure readings: note absence of hypotension. 2. Intake maintained and output negligible. 3. Biochemical findings (rising blood urea and serum potassium, and falling plasma chlorides). 4. Haemoglobin readings. Death occurred on the 6th morning.

Cardiovascular system. The valves, chambers and muscles of the heart (280 g.) appeared healthy. The coronary arteries, the aorta and branches were smooth walled, elastic and free from atheroma. There was postmortem clot in the pulmonary artery.

Respiratory system. Apart from a moderate degree of marginal emphysema and partial collapse of their bases, the lungs appeared healthy. The mediastinal lymph-nodes were normal.

Alimentary system. The tongue was moderately furred. The pharynx, oesophagus, stomach and intestines all appeared normal. The liver (1920 g.)

appeared healthy. The bile-ducts were patent. The pancreas appeared healthy.

The spleen (300 g.) was enlarged, its pulp firm, the Malpighian bodies prominent. The adrenals appeared normal. The thyroid gland was rich in colloid. The breasts were heavy and tense and when incised gave out spurts of milk. The vertebral bone-marrow was pale. The right femur contained pink marrow in its upper two thirds, but did not show any gross medullary bone resorption. The brain (1280 g.) and its basal vessels were normal. There was a haemorrhagic oedema of the pituitary stalk. The hypothalamus was not engorged. The pituitary gland was fixed whole in

Zenker-formol solution and then bisected. After the chromate had been washed out the cut surface of the gland presented a massive anaemic infarction of the pars anterior bordered by a thin subcapsular haemorrhagic zone. The naked-eye appearance was identical with that of the renal coagulative necrosis (Fig. 2).

MICROSCOPIC FINDINGS.

Pituitary. The anterior lobe shows a massive coagulative necrosis which has left only a few surviving cells scattered under the capsule and in the posterosuperior angle beneath and in front of the stalk. The pituitary cells have lost their haematoxyphil nuclear staining. The central sinusoids are empty but those nearer the periphery contain numerous polymorphonuclear leucocytes (many of them vacuolated and showing pyknotic nuclei) (Fig. 3). The sinusoids supplying the surviving cells are engorged. The basement-membranes can still be stained by aniline blue so as to show up the 'skeleton' of the infarcted area. And many of the parenchymatous cells, which stain a uniform pink with haematoxylin and eosin, show ghostly remnants of nuclei and granules when stained by Mallory's or Biggart's method. The pars intermedia and posterior appear normal. The sinusoids of the stalk are intensely engorged and the interstitial tissue at its upper end is flooded with red cells. The arterioles are not thrombosed. But the veins of the stalk, both large and small, contain varying types of thrombus: amorphous hyalinized red-cell masses, organizing fibrin and entangled cells, and conglutinated red cells (Fig. 4). The age of the pars anterior necrosis, judged by the parenchymatous karyolysis, the polymorphonuclear infiltration and the absence of secondary atrophy lies between 3 and 9 days and tallies with the 6 days' survival after delivery.

Kidneys. The cortex and columns of Bertini show a widespread ischaemic coagulative necrosis split up by slender streaks of surviving renal tissue which is also present as a thin layer underneath the capsule (Fig. 5). The medulla is congested but nowhere infarcted. In the depths of the infarcted cortex, karyolysis is complete and there is no leucocytic infiltration; the ghosts of glomeruli, tubules and vessels (including dead interlobular arteries distended with hyalinized fibrin thrombus) are readily made out (Fig. 6).

The edges of the infarcted areas show a heavy interstitial infiltration with degenerate fatty polymorphonuclears and occasional patches of interstitial haemorrhage. The zone of demarcation between living and dead cortex is surprisingly sharp. It cuts right across the renal structures so as to leave some arterioles and some glomeruli bisected into a living and a dead half. There is not any evidence in the living glomeruli of any previous widespread ischaemic changes nor of any eclamptic oedema of the capillary basement membranes. The living tubules contain cast material and desquamated cells, a few of the living cells are fatty. There are occasional terminal interlobular and afferent arterioles in the living cortex which are distended and occluded by hyalinized material (resembling fused red cells). These vessels are surrounded by a small zone of polymorphonuclears and histiocytes. Elastic stains confirm the extraordinary, almost "paralytic" dilation of some of the interlobular arteries, particularly in the infarcts (Fig. 6). These stand out in all sections. Non-thrombosed interlobular arteries at the edge of the infarcted tissue show commencing acute necrosis of their walls and a surrounding zone of radially grouped pyknotic leucocytes—a typical acute arteritis (Fig. 7). The interlobular and arcuate arteries and veins are free from thrombus or disease, some interlobular arteries show a mild elastosis. The age of the infarcts, judged by the degree of parenchymatous karyolysis and marginal interstitial polymorphonuclear infiltration, tallies well with the clinical history of 6 days anuria. Thus, the renal necrosis judged histologically is likely to be of the same age as the pituitary necrosis.

The picture as a whole suggests the following possible interpretation of the train of events. The infarcted terrain is that supplied by the interlobular arteries. These appear to have been primarily obstructed by stasis leading to thrombosis which has spread both backwards and forwards along these vessels. The grossly diminished or complete loss of blood-flow led to renal functional failure and ischaemic necrosis. How the stasis arose and the significance of the arteritis are discussed later.

Pancreas. The glands and islets are normal. But there is a striking arteritis in all stages of development which involves many of the small and large vessels. The earlier lesions consist of fibrinoid

necrosis of a segment of the adventitial coat. The necrotic collagen is infiltrated with pyknotic nuclei. The next development seen is an extension of the necrosis into the media and a brisk perivascular inflammation. In the advanced stages, the whole of the adventitia and much of the media is swollen and replaced by fibrinoid material and somewhat radially arranged pyknotic nuclei (Fig. 8). The perivascular interstitial tissue is heavily infiltrated with histiocytes and polymorphonuclears some of which extend into the surrounding pancreatic glandular tissue. The lumen of the vessels is free from thrombus. The only thrombosed vessels present are a few small arterioles and venules lying in the neighbourhood of a gravely involved larger vessel.

Liver. There is a widespread fine fatty droplet change affecting all zones of the lobules and, in addition, occasional centrilobular focal necroses (small collections of dead liver cells infiltrated with fresh polymorphonuclears). There is no eclamptic periportal haemorrhagic necrosis.

Uterine wall. Some of the subperitoneal muscle fibres are vacuolated and show glycogenic degeneration of their nuclei. This same layer is rendered prominent by the presence of numerous interstitial haemorrhages. Many uterine veins are distended and filled with aseptic fibrin thrombus showing, as yet, practically no organization. The uterus is lined by fibrin, entangled red cells and masses of pyknotic nuclei derived from decidual cells and polymorphonuclears. There are scattered cystic healthy endometrial glands of the basalis layer.

Right ovarian vein. This is distended by thrombus which consists chiefly of massed red cells (still containing haemoglobin) traversed by strands of fibrin, conglomerated platelets and entangled leucocytes. It all looks of recent formation (less than 5 days). The muscularis has been thinned by distension. The adventitia is oedematous and contains fibrin and free red cells which have spread a little way into the surrounding fatty connective-tissue.

Spleen. There is a moderate increase of polymorphonuclears in the pulp and occasional megakaryocytes in the sinusoids.

Gall bladder. The outer connective-tissue coat shows a mild perivascular inflammatory infiltration with lymphocytes and neutrophil and eosinophil polymorphonuclear leucocytes.

Breast. The acini show a well-marked lactation hyperplasia. Their lumens and lining cells are distended with fat droplets.

Sections of the lung, heart-muscle, hypothalamus, bone-marrow, cervix, adrenal, thyroid and left ovary (which contains a well vascularized corpus luteum of advanced pregnancy) do not show any essential pathological changes.

It is clear from the above clinical history and the naked-eye and microscopic postmortem findings that death was due to renal failure brought on by the massive renal necrosis which had most likely occurred 6 days previously at the time of the concealed accidental haemorrhage. One cannot gauge to what extent the pituitary necrosis, which had occurred at the same time, contributed towards the death.

DISCUSSION.

Sheehan¹ found 11 cases of postpartum necrosis of the anterior pituitary in a consecutive series of 59 postmortem examinations of women dying in the puerperium. Thus, there is about a 1 in 5 chance of its occurrence together with renal cortical necrosis. He also found that in 24 of 28 recorded cases there was a history of haemorrhage at delivery. All these patients were "collapsed." Since haemorrhage and "collapse" are present in almost all cases of renal cortical necrosis, the chances of its coincidence with pituitary necrosis must be even higher than 1 in 5. Sheehan thought the pituitary necrosis resulted from haemorrhage and "collapse" rather than "toxaemia."

Tomlinson² described a case of combined pituitary and renal necrosis in a multipara aged 28, who was admitted in the 38th week of her third pregnancy suffering from a urinary tract infection. Following forceps delivery of a stillborn infant and manual removal of the placenta she went into severe shock. She developed anuria and died 6 days later of uraemia. Sheldon and Hertig³ described 2 cases of renal cortical necrosis in which postmortem examination

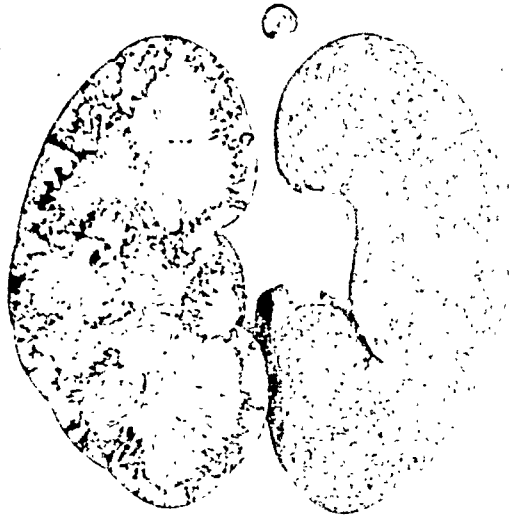


FIG. 2.

Right kidney and pituitary. (Photograph reduced to half natural size.) Widespread pale cortical necrosis bordered by a thin hyperaemic zone, mottled subcapsular surface, ischaemic cut surface of pituitary gland.

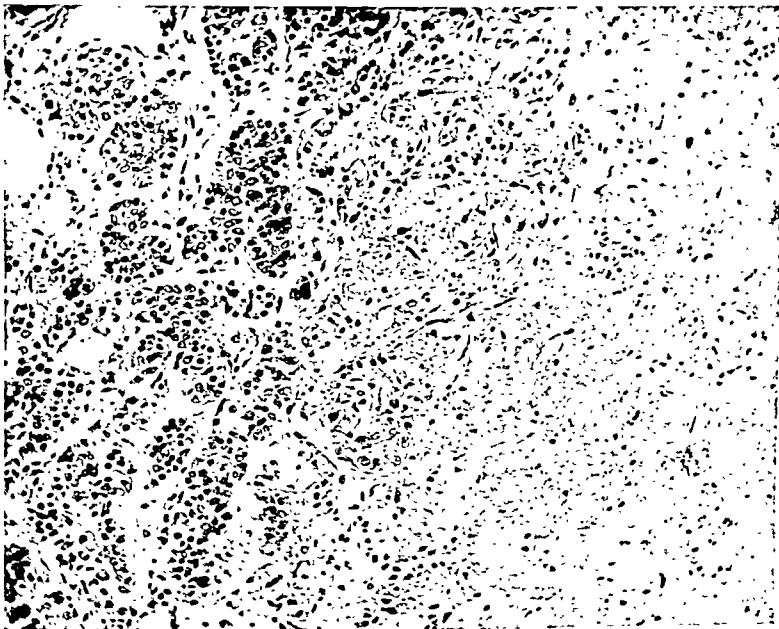


FIG. 3.

Pituitary gland. (Photomicrograph [$\times 175$], Formol-Zenker, Haematoxylin and Eosin.) Border between living cells of the pars anterior to the left and dead to the right.



FIG. 4.

Pituitary stalk. (Photomicrograph [$\times 90$], Formol-Zenker, Haematoxylin and Eosin.) Thrombosed veins in the pituitary stalk. The arteries and arterioles are patent.

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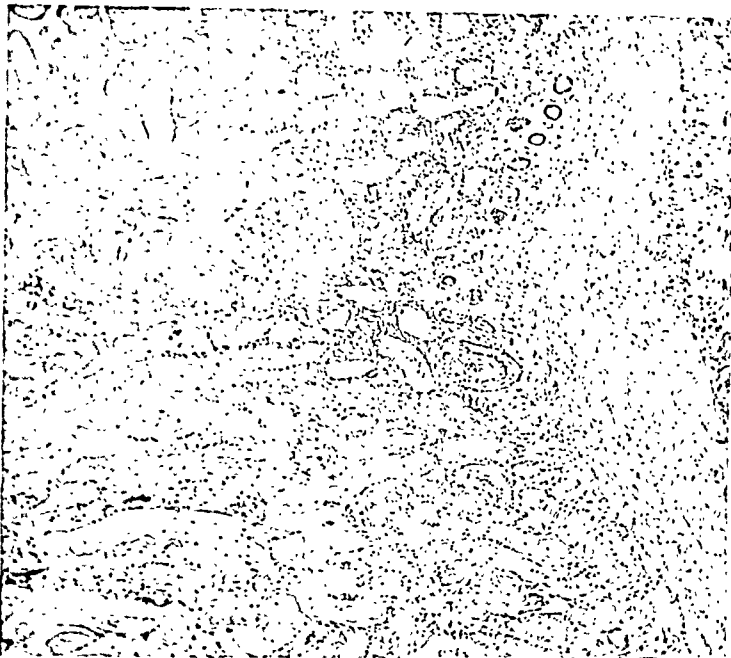


FIG. 5.

Kidney. (Photomicrograph [$\times 90$], Formol-Zenker, Haematoxylin and Eosin.) Oedematous congested renal capsule separated by a thin hyperaemic zone infiltrated with leucocytes from underlying infarcted cortex.

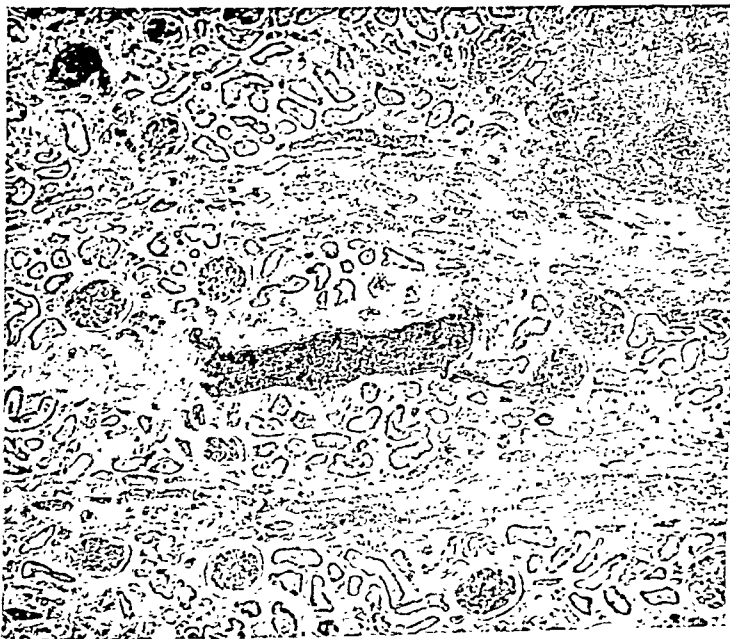


FIG. 6.

Kidney. (Photomicrograph [$\times 60$], Formol-Zenker, Haematoxylin and Eosin.) Distended thrombosed interlobular artery giving off two afferent arterioles which are also thrombosed, in the infarcted cortex.



FIG. 7.

Kidney. (Photomicrograph [$\times 175$], Formol-Zenker, Haematoxylin and Eosin.) Acute arteritis of an interlobular artery at the edge of an infarcted area.



FIG. 8.

Pancreas. (Photomicrograph [$\times 90$], Formol-Zenker, Haematoxylin and Eosin.) Acute necrotizing arteritis with inflammation spreading into the interstitial tissue.

revealed anterior pituitary necrosis as well. The 1st was a multipara aged 33 who went into labour 7 weeks from term following signs of toxic separation of the placenta. She died 7 days later having passed only 30 c.cm. of urine since delivery. The 2nd was a multipara, aged 40, who went into labour 8 weeks from term following signs of toxic separation of the placenta. She died 11 days later, having passed 53 c.cm. urine since delivery.

Duff and More⁴ reviewed the literature up to date on symmetrical cortical renal necrosis. They found a total of 48 authentic cases following pregnancy. Pituitary necrosis was not described in any of these. But, after reading the case histories, one is inclined to believe that in very few, if any, was the pituitary gland examined microscopically. Since 1941, 6 cases of renal necrosis have been described and an associated pituitary necrosis found in 3 of them, as quoted above. It seems reasonable to presume that a careful examination in future cases of renal necrosis will reveal a frequent association with pituitary necrosis, and that our case, and those of Tomlinson, Sheldon and Hertig, are by no means the rarities they at present appear to be.

Each of these 2 conditions has been excellently reviewed^{1,4} already, but various points in our own case are worth further discussion.

Pituitary gland. The haemorrhagic state of the stalk and the presence in it of thrombosed sinusoids were also seen by Sheldon and Hertig. The anatomy of the venous sinusoids of the stalk has been carefully investigated by Wislocki and King.⁵ They proved that these are "portal" veins which supply the sinusoids of the pars anterior together with branches of the superior hypophyseal arteries. The sinusoids of the pars anterior drain into the cavernous sinus. Popa and Fielding,⁶ who first

identified the pituitary "portal" veins, believed, on the contrary, that the direction of flow was towards the hypothalamus. The findings in this case of a necrotic pars anterior and a normal hypothalamus confirm Wislocki's view of the direction of flow, and at the same time imply that the pituitary "portal" veins play a much bigger part than the arteries in the blood supply of the pars anterior, at all events, in late pregnancy.

Accidental haemorrhage. We could not find a cause for the retroplacental haemorrhage. The histology of the uterus ruled out sepsis. There was not any evidence of eclampsia or essential hypertension or glomerulonephritis in the kidneys. The section of right ovarian vein showed the thrombosis to be of too recent origin to have played any precipitating role.

Renal necrosis. It is possible to suggest a vascular mechanism without resort to toxins. Duff and More⁴ concluded in their review that "some unknown factors, given suitable conditions, cause disturbances in the terminal arteries of the renal cortex, the damage done depending on the sensitivity of these vessels to irritation. That in pregnancy these vessels may become hypersensitive. That varying hypersensitivity and intensity of irritation may lead to a series of vascular degenerative changes, including necrosis of the wall and thrombosis. That the same sized arteries of other organs are also hypersensitive; though to a less degree." It seems to us that the unknown factor may be simply the reflex vasoconstriction which follows blood loss and is directed towards accommodating the vessels to the reduced blood volume and maintenance of the mean arterial pressure. The point that there is a definite association of symmetrical renal necrosis with haemorrhage and collapse needs no labouring.

Evidence for a reflex vasoconstriction can be seen that among Duff and More's 48 cases of renal necrosis, in the 21 which followed accidental haemorrhage, the average blood-pressure was 170/109 (the lowest recorded was 118/50).

In their studies on the renal circulation in shock Lauson, Bradley and Cournand⁷ found evidence of a considerable degree of renal vasoconstriction in most cases (including the post-haemorrhagic state), and indications that blood is shunted away from the kidneys. (thus confirming the generally held view that the oliguria or anuria of shock results from decreased circulation through the kidneys). We have some clinical evidence in our own case that there was a generalized vasoconstriction following the 26 ounces retroplacental haemorrhage in that the patient was "shocked," pale, anuric and maintained a blood-pressure of 150/80. Granted the hypersensitivity of the terminal renal arteries in pregnancy, renal arteriolar spasm would undoubtedly follow. Whereas relief of the spasm is followed normally by continuation of the circulation at a reasonable renal filtration pressure, in this case there appears to have been a block due to massed red cell thrombus. The possible factors responsible for this might have been intensity of the vasoconstriction, or a paralytic vascular dilatation with stasis following the spasm (Scriver and Oertel⁸) or the increased coagulability of the blood said to occur in the postpartum state. Outside the kidneys, the centrilobular hepatic focal necroses are further evidence of a reduced blood flow as found by Bywaters⁹ in his studies of the liver in crushing injuries. It is interesting to note that the degree of anaemia 5 g. per cent haemoglobin, would further aggravate the ischaemic state of the kidneys and other sensitive viscera. In the 9 cases of renal necrosis in the literature in

which the haemoglobin level was given, the average figure was 6 g. per cent. This level, after discounting the "physiological" low normal value in late pregnancy and the drop due to haemorrhage, suggests that these patients were anaemic before their catastrophe.

Arteritis. Apart from haemorrhages in the heart, brain and stomach, foci of necrosis round vessels in the pancreas,⁴ and in the caecum and adrenals² have been described. They have been attributed either to vascular spasm or to the action of some toxic substance. The pancreatic arteritis in our case (as well as the renal) appeared definitely to have commenced in the adventitia. The age of the lesion, judged by the freshness of the polymorphonuclears bordering the necrotic areas, appears on the whole to be definitely less rather than more than 6 days. It is conceivable that it is an ischaemic necrosis resulting from diminished blood flow through the vasa vasorum associated with spasm both of the vasa and the vessel itself. The uraemic state of the patient might account for any "toxic" element in the aetiology of the arteritis. It is relevant to recall that Byrom¹⁰ produced renal cortical necrosis and a necrotizing arteritis of the renal and gastric arteries of rats by repeated subcutaneous injections of vasopressin.

Any factor which causes complete obstruction to the blood flow through the terminal renal arteries will produce a similar ultimate pathological picture of symmetrical renal coagulative necrosis. And since not all cases of such renal necrosis are associated with haemorrhage, or for that matter with pregnancy, there must be more than one mechanism which obstructs the renal circulation. Similarly, arteritis can result from other causes than spasm (for example following sulphonamide hypersensitivity).

But the reflex vasoconstrictive mechanism

described above seems to us to fit in well with the typical findings in cases associated with accidental haemorrhage.

CONCLUSION.

We suggest that, as in the case of pituitary necrosis, pregnancy renders the patient liable to suffer symmetrical cortical necrosis as a complication of haemorrhage and collapse. Though the latter is a less frequent development than the former, it is not surprising to find the two conditions in common association. The altered circulatory state produces spasm and thrombosis of the renal terminal arterial segments, stasis and thrombosis of the stalk segment of the pituitary "portal" venous system. The resultant anoxia of the tissues supplied by these vessels may be aggravated by the anaemia associated with many of these cases. One may find further evidence of anoxic necrosis in the liver and possibly in the walls of small arteries (in the pancreas and adrenals).

ACKNOWLEDGMENTS.

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Infertility in Women

BY

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THE subfertility problem is at long last being tackled with considerable zest in this country, as is evidenced by clinics that are springing up, manned by enthusiastic personnel. This being so, it may be suitable at this stage to pause for a while in order to consider the present position as regards the investigation of this complex subject.

Just now it looks as if there might develop a growing danger in some quarters of a tendency to over-elaboration of technique, for it would seem that the bulk of the people of this country, whether urban or rural, is not ripe for as thorough investigations as those undertaken by our transatlantic friends; nor can the majority of them pack their suitcases and travel to centres where the "minimal sterility survey", as for example that drawn up by E. C. Hamblen, occupies at least 3 whole days. Again, it may be asked, is success always eugenically expedient in many of these stubbornly subfertile couples, when quality not quantity is surely the desired goal."

The investigation of subfertility falls into 3 main hands:

A. The family practitioner.

B. (1) The smaller of the provincial clinics, such as those sponsored by the Family Planning Association. The outstanding example of these is one that has been run since 1931 by Dr. Margaret Jackson,¹ with the collaboration, as biologist, of Mrs. Clara Harvey, B.Sc.

B. (2) The ultra-specialized clinic, which can call on the services of a gynaecologist, andrologist, biochemist, biologist, patholo-

gist, radiologist, endocrinologist, and psychiatrist, all working together.

It is to these clinics that we should look in the future for the regular publication of their research work and of their data for it is only by the pooling of all available results that we may hope to attain success.

(A) THE FAMILY PRACTITIONER.

Some subfertile couples are somewhat shy of asking their practitioner's advice on their problem and prefer to go straight to a clinic for investigation. Such a clinic rightly is always anxious to refer these cases back to their doctor for subsequent treatment, injections, etc.

Other couples realize that no one understands their home life and their habits better than their family medical adviser, and so they tend to ask his help, and frequently sooner in their married life than those who go straight to the clinic. If the doctor has the time and the assiduity, it is surprising how many of his attending subfertile couples he can handle with success, without ever referring them to a specialized clinic. By the time he has taken a careful history, carried out a thorough medical overhaul and a local examination of both partners, he will probably have encountered several subfertility factors, which he can set about correcting.

Frequently some minor gynaecological condition calls for suitable adjustment: or, again, advice about the correct time for coitus, the taking of the daily rectal waking

temperature, with an explanation of the preluteal drop, may be the next step. The carefully judged administration of thyroid in certain cases, or of dienoestrol with ethisterone, or of the gonadotrophic hormones in others, will call for a working knowledge of the sex-hormones. Possibly the suggesting of a glucose saline precoital douche may be followed by success or, if not, he may then be able to carry out for himself a Huhner's or Sims' post-coital test, followed by a rough sperm count. At this stage the practitioner may decide that an endometrial biopsy or a tubal insufflation or a hysterosalpingogram is indicated. This is when he will probably call in the clinic's help, if he has one to turn to in the neighbourhood.

(B) THE SUBFERTILITY CLINIC.

If the problem, however, is a more complex one, then it is usual to carry out a far more exhaustive investigation, depending on the facilities available at that particular clinic. The co-ordination and interpretation of the results of these examinations usually locates one or more subfertility factors among the following groups:

I. Pelvic pathological lesions, either inflammatory or neoplastic (the surgical treatment of these conditions will not be discussed in this paper).

II. The cervical factor—the nature of the cervical plug of mucus and the reception of the inseminated spermatozoa.

III. The tubal factor—possibly a case of lack of function; of occlusion; or of spasm.

IV. The endocrine aspect on the female side, with its varying effects on the reproductive function.

It should be possible to carry out the following special investigations at the clinic:

I. Examination of the vaginal fluid, and the possible taking of vaginal smears.

II. Tubal insufflation.

III. Hysterosalpingography.

IV. Endometrial biopsy.

V. Post-coital test, whether after Huhner's or Sims' methods.

VI. Seminal analysis.

VII. The investigation of endocrine dysfunction, hormone analysis, etc.

I. The examination of the vaginal fluid is briefly with the object of excluding trichomonas vaginalis, or monilia, and with finding the pH value.

The vaginal smear—this diagnostic method has not, so far, been employed as extensively in this country as in America, where the technique of Papanicolaou and Shorr is usually followed.² The smears may be taken right through the cycle, showing a varying cytology and a rhythmic cyclicity in the various phases.

i. Menstrual phase smear.

ii. Postmenstrual (early proliferative) smear, 4–5 days.

iii. Pre-ovulation smear (late proliferative), 11–12 days.

iv. Ovulatory type smear, 13–14 days.

v. Post-ovulatory smear, 17–19 days.

vi. Premenstrual or secretory phase, from 19th day onwards.

From comparison of the above, help is claimed in estimating ovarian activity, in assessing the effectiveness of oestrogenic, androgenic, and gonadotrophic preparations, and in determining ovulation.

II. Tubal insufflation—Anyone who has seen a case of pelvic peritonitis following either insufflation or hysterosalpingography, will proceed very carefully in every case, and more so in any suspect case. Malpas considers "in the presence of inflammatory appendage disease or its sequelae neither procedure should be carried out except after very serious consideration, and then only if a vigorous bimanual examination and a course of short

wave pelvic diathermy have demonstrated complete quiescence".³ The test is best performed either between the 4th and 10th day after the end of the period, or in the premenstrual phase, when a biopsy of the endometrium can be taken at the same time. The findings at insufflation are:

i. Normal patency—the pressure reaches 60 to 120 mm.Hg. and then rapidly falls.

ii. Non-patency.

iii. Spasm—the escape pressure is high, the flow does not take place at once but, when it does so, its fall is rapid. If the test is repeated later, normal patency is shown.

iv. Stenosis—the escape pressure is high, the fall is slow, and repetition of the test gives a similar result. If a kymograph machine is being used, which is the best as the peristalsis of tubal function is observed, then the tracing will be according to the above.

Sharman in his series of nearly 500 cases found several erroneous results.⁴ In 60 non-patent to insufflation he found 6 patent to hysterosalpingography. So, in repeated insufflation cases, he drew the following conclusions:

i. There was not any material change in the tracing of a patient insufflated on 20 consecutive days (menstruation intervening).

ii. Anaesthesia had no effect on the tracing.

iii. Around ovulation time there is sometimes more active or more frequent peristalsis.

iv. No great variance in the tracing in repeat insufflations is found, even after several months, either in the level at which patency is established, or in the appearance of the tubal contraction-waves.

v. Repeated insufflations have also shown that spasm, whether of lesser or major degree, is not a constant state and

that many tracings may show a normal patency.

vi. The result of a single insufflation, with or without anaesthesia, showing apparent non-patency, cannot be depended upon.

vii. As a therapeutic measure it was found that, of the ensuing pregnancies, 36 per cent became pregnant in 3 months and 50 per cent became pregnant in 6 months.

III. *Hysterosalpingography*. Where an X-ray apparatus is handy, and the extra expense is not a drawback, there is no doubt that a higher percentage of cases subsequently become pregnant after hysterosalpingography than after tubal insufflation. The test is usually done 4 to 10 days after the end of the period. The use of anaesthesia is still debatable—many prefer atropine or morphine, $\frac{3}{4}$ of an hour beforehand, without anaesthesia. There are many types of instruments, each gynaecologist usually keeping to one pattern. Neohydriol is probably the best type of oil, care being taken not to use too much pressure or too much oil. It is always a help to use the screen first—watching the oil passing along the tubes, usually after 5 to 6 c.cm. have been slowly injected. Sometimes there is intense spasm, when nothing passes through the sphincter muscles at the cornua. Many and various are the findings by this technique, with suitable treatment being called for of salpingography, intra-uterine tubal implantation, shortening of the round ligaments, myomectomy—especially if the fibroid is submucous in type—etc. From the above considerations the accurate interpretation of a hysterosalpingogram may be difficult. It may show blockage when none exists, or its interpretation may be so difficult that an accurate conclusion cannot be reached. On the other hand it may show patency when insufflation has indicated blockage, and, in non-patent

tubes it will reveal the precise site of blockage. As Malpas says "both procedures, insufflation and salpingography, are complementary the one to the other and essentially diagnostic. Their use as primary therapeutic measures is likely to lead to many disappointments, and will tend to bring them into discredit. In general it may be said that, if the tubes are demonstrated patent, conception will ultimately occur in about half the cases. If careful steps can be taken to exclude the other causes of sterility—azoospermia, anovulatory cycles, endometrial tuberculosis—then the proportion of pregnancies following positive tests will very likely be still higher."³

IV. *Endometrial biopsy*. This is carried out in the premenstrual phase, usually between the 24th and 26th days of a 28 day cycle, with a Sharman curette, when there is no need for anaesthesia; but it is a procedure that should be done with the utmost gentleness. It is impossible to discuss the findings here, but briefly it may be said that it is rare to find an endometrium which shows no sign of progestational change, though in many this appears to be inadequate or incomplete. It would seem that the endometrial biopsy does not provide a complete answer to the question as to whether normal ovulation has occurred, though it does provide important information about ovarian function and about endometrial response. Occasionally no period has followed the taking of a biopsy, presumably after fertilization has occurred. Endometrial biopsy not only does not interfere with pregnancy but apparently encourages decidual formation. In Sharman's recent series, 335 showed the normal endometrial appearances of the premenstrual or post-ovulatory stage, and 23 exhibited definite anovular cycles.⁴ Of these 23, none became pregnant during the period of study, and only 2 under treat-

ment. Anovular menstruation is therefore a major infertility factor, when it occurs, although its incidence is low.

V. *The Post-coital test*. Recently Rubin has stated "our results in combating childlessness may be expected to improve the more we are prepared to investigate the causes of the infertile mating, rather than the infertile individual". This wise dictum, confirmed by so many, has tended to make some workers focus a great deal more of their attention on the cervix uteri and its secretion, the plug of cervical mucus. Barton and Wiesner^{5,6} have considerably developed their technique of the Sims post-coital test, basing their work on a paper of Marion Sims of 1868. They describe the "ovulatory phase" cervical mucus plug as "a cordon of mucus which clings in a fairly well delineated cascade to the surface of the cervix. It is perfectly clear, colourless, rather viscous, and it has a low vapour pressure so that it can be examined at leisure without change by rapid drying, and it is invariably alkaline." They proceed to describe the cyclical changes in the appearance of the cervical mucus, with changes in the volume, the nature, and the opacity of the secretion, with the density of the sloughed cervical cells and of the leucocytes, in the second phase of the menstrual cycle, which may become of diagnostic importance, as a mirror of ovarian function. From research work on the hyperfertile male we may look for more help and guidance in the future. There can be few more interesting phenomena to watch through the microscope than when, under the centre of a vaseline-ringed cover slip, has been placed a drop of ovulatory cervical mucus. Then through a gap in the ring is placed a drop of semen, first on one side from one subject, then on another side from another subject, through another gap. Barton and Wiesner have described in detail their observations

of the cervical mucus, concluding that "first, spermatozoa penetrate into the mucus of their own power and motility. This penetration is attempted by many but achieved by only a comparatively small proportion of the sperms approaching the interlace. This again corresponds to observations *in vivo* where the total number of sperms penetrating into the cervix does not exceed a small proportion of the ejaculate. Thirdly, the spermatozoa which have penetrated into the mucus live longer than any of them do in the seminal fluid under comparable conditions". In summing up they are of the opinion that the cervix does not function as a mere passage or in a crude mechanical way, but as a highly developed filter and preserver for those sperms which satisfy certain stringent conditions. It is the secretion of the cervical mucus that is of paramount importance, depending on oestrogenic secretion for its presence and healthiness, quite apart from local pathological conditions, such as endocervicitis, which much impedes or inhibits cervical invasion. It is when the cervical mucus is normal, or nearly normal, and sperm invasion still fails that artificial cervical insemination may be considered. First, the husband's cells are treated to improve motility, and then, provided they show a reasonable degree of initial motility when collected—either directly or from the vaginal pool—there is carried out a deposition within the cervical canal of a small quantity of the husband's semen, in order to secure better invasion. This deposition of the husband's semen may be indicated apart from the above impaired cervical invasion by spermatozoa:

i. Where treatment of impotence has failed.

ii. Where the husband fails to ejaculate during intercourse or emits only a minute quantity of azoospermic liquid.

iii. In certain cases of incurable dyspareunia.

VI. *Seminal analysis* will be considered in the male section of this paper.

VII. *The investigation of endocrine dysfunction.* So vast has become the literature on the hormonal side of subfertility that even the briefest sketch of the problem and its treatment does not fall within the scope of this short sketch. It may be said that, as regards treatment, some of the newer preparations have begun to give better results. For example the microcrystalline suspension of oestrogenic hormones produces its action in a more gradual and sustained manner.

Again the combination of chorionic gonadotrophin and anterior pituitary-like hormone, in the compound synapoidin has proved useful.

Irradiation therapy, both of the pituitary and ovaries, as a supplement to hormone treatment, has been more advocated in America than anywhere. As regards the ovarian treatment, the Kaplan technique has met with some success in severe cases of amenorrhoea. In this country Green-Armytage and Carter Braine have reported a series of 7 cases with amenorrhoea up to 16 months in duration, 4 of whom conceived, and went to term, producing healthy babies.

Among many other aspects of the endocrine side of the problem, the relation between fecundity and body temperature has come to be recognized as an important factor in dating ovulation and so deciding the optimum time for coitus. Van de Velde (in 1904 and 1929) showed that in the normal woman the body temperature is relatively low during the first and relatively high during the second half of the menstrual cycle. In this connexion Raymond Greene and Nieburgs, summarizing their findings,

said: "The temperature variations during the menstrual cycle closely correspond to changes in glandular activity, particularly of the pituitary, gonadotrophic, follicular and luteal hormones. It is suggested that the decrease of temperature is an expression of oestrogenic activity, where temperature rise is caused by the corpus luteum. Usually on the 14th day before menstruation oestrogen excretion reaches its highest peak, causing the sudden drop in temperature. This is followed by a vigorous release of luteinizing hormone from the anterior pituitary, which produces ovulation and corpus luteum formation, with increased progesterin excretion. During the luteal phase the temperature rises to a level between 99° and 100°F. or more and remains at this level with slight fluctuations throughout the whole luteal phase. It declines 1 or 2 days before the onset of the menses."*

From this very superficial sketch of a very important national problem will be seen the crying need for accurate diagnosis, which will surely result from patient research into its many sub-sections, to mention only ovulation, the determination of faulty oögenesis and its promise of correction by hormonal administration, the biology of the cervix uteri, the whole question of hormonal analysis, and the bearing of the minor endocrinopathies and their suitable therapeutic adjustment.

In passing it might be wise to reflect on the conclusions of the Peckham Health Centre in their recent "Observations on the population question":*

1. That "parenthood", that is to say, biological growth and differentiation through the family, is a natural process with powerful urges operating through both male and female, but only in health.

2. That deep and primary biological causes underlie the frustration of parenthood.

3. That treatment of symptoms will not eradicate the cause of the symptoms, and so lead to cure of the disorder.

4. That, so far, all administration pertaining to parenthood—antenatal care, provision for confinement, child welfare, etc., all dealt with as separate items—has been approached from the negative point of view of correction—the medical approach. If parenthood is to appear to the public as desirable, it must be approached from the positive point of view of cultivation, the biological approach.

There is a great deal of common sense behind these observations; there is much to be learned by combined research and sound team work in the newly organized clinics, and there will have to be a nation-wide propaganda campaign inaugurated, with the Government deciding how best maternity can be both encouraged and honoured and made practicable.

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Male Infertility

BY

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THE necessity for an examination of the husband, when the wife has failed to conceive, is now widely recognized, and it is no longer necessary to stress this point. There are no statistics by which the incidence of male fertility in this country can be assessed, but it is probable that in one-fifth of all barren unions the husband is mainly responsible and that in about two-thirds of them his infertility is a contributory factor. In the majority of cases the clinical examination does not reveal abnormality, and the true state of affairs is only discovered when the semen is analysed. Cases in which such obvious and gross lesions as hypogonadism, hypopituitarism, retained testis and induration of the epididymes are found are in the minority, and it is therefore never possible to assure a patient that he is fertile after the preliminary examination alone. This assurance can only be given subsequent to the semen analysis.

The preliminary investigation must not be confined to the genital tract, since lesions in other parts of the body may have repercussions on the germinal epithelium. A careful history must be taken of all past illnesses, and particularly of gross infections in recent years. The occupation of the patient should also be noted, because it is likely that some occupations which entail exposure to the action of various chemicals, or to electrical rays and excessive heat are dangerous to fertility. The mode of life and habits of the patient must also be noted.

Because conception depends on the presence of spermatozoa in the female passages at the time of ovulation, the husband should be questioned as to the

frequency and effectiveness of sexual intercourse. Poor potency and infrequent intercourse is a contributory factor in many barren marriages, for if sexual union takes place on an average only once a month the chances of its coinciding with ovulation are considerably reduced. Unfortunately, poor potency is extremely common in this country and many of the husbands who are under treatment for reduced fertility also need help for sexual difficulties. Sometimes the latter is the direct result of the former. When a man's fertility is questioned he often develops the fear that there may also be something wrong with his virility, and as a result his sexual difficulties are increased. Premature ejaculation is perhaps the commonest of these difficulties, but although it reduces the likelihood of conception, it does not prevent it. It is important to make certain that the sexual act is completed, for absence of emission is by no means uncommon. Sometimes the patient himself is completely unaware of the fact that he has no emission, and it is only revealed after he has been asked to obtain semen for analysis. This grave defect is not due to the presence of any physical lesion but to some sexual aberration. In a group of 35 cases of this type analysis revealed 10 cases of severe sexual perversions, including 3 cases of homosexuality and 3 of sadomasochism. Only 4 of them responded to treatment.

Semen analysis. Specimens should be obtained either by masturbation or by coitus interruptus. Chemicals are present in rubber sheaths which bring the spermatozoa to a standstill and they should consequently

never be used. The specimen is collected in a glass bottle or tube warmed to blood-heat. It should then be wrapped in cotton wool, placed in a box and delivered at the laboratories within 3 hours. It is unnecessary to insist on more than 3 or 4 days of continence prior to the collecting of the specimen. Semen analysis has made such progress in recent years that it has now become a matter for experts. In this paper only a few of the main points in the examination can be dealt with.

The volume is usually between 2 and 5 c.cm. Because the accessory sexual glands are responsible for the bulk of the semen, it is generally assumed that when the volume is large the density of spermatozoa will be low. This is not necessarily the case. Dr. C. Harvey, seminologist at the Exeter Clinic, states that she has not found any relationship between density and volume, or volume and fertility, until the lower limits are reached. Undue emphasis was laid in earlier American publications on the factor of density, and the statement that unless 60,000,000 spermatozoa are found per c.cm. the husband must be considered subfertile is certainly erroneous. Conception frequently occurs with much lower counts. It must also be remembered that different samples from the same patient show great variations of density. This may partly be explained by the testes making different contributions to the semen, and it renders it difficult to estimate the results of treatment when this is being given for oligozoospermia. We have even had cases in which complete azoospermia was revealed on one occasion and on another plentiful spermatozoa were found. It is possible that some of these extreme variations may be the result of temporary occlusion of some of the ducts. There have also been cases in which husbands have been able to supply good specimens of semen by masturbation, but

when post-coital tests have been carried out on their wives no spermatozoa could be found.

After the count, motility and viability of the spermatozoa have been determined, their morphology must be carefully studied, for it is the quality of the spermatozoa rather than their number which is of primary importance. If more than 25 per cent of the spermatozoa are found to be abnormal the fertility of the husband must be suspected. Abnormal forms appear in the seminal fluid as the result of imperfect spermatogenesis, arrest of spermateliosis at an early stage with premature detachment from the germinal epithelium, and of the degeneration of what was originally a normal sperm. Cells of the spermatocyte and spermatid type are often found in association with the abnormal spermatozoa. If leucocytes are also present in considerable numbers arrangements must be made for a bacteriological investigation of the semen, as well as for a more searching examination of the genital tract. Prostatic fluid should be expressed by massage and the urine cultured. Unfortunately, it is often difficult to decide whether positive bacteriological findings are the actual cause of the infertility, or whether they are the result of accidental contamination of the semen.

. *Testicular biopsy.* The microscopic examination of a small fragment of testis yields very valuable information. It is an operation which can be carried out under a local anaesthetic, or under pentothal, and it imposes very little hardship upon the patient. Having exposed the glistening surface of the testis through a half-inch incision, it is punctured with a pointed tenotome and the button of testicular tissue which extrudes is removed with iridectomy scissors. One of the lessons which have been learned from biopsy is that wide variations are often to be found in different areas of the testis; at one point the tubules may

be found completely degenerated and at another active spermatogenesis may still be in progress. When it is necessary to differentiate between an azoospermia due to aspermatogenesis and one resulting from blockage of the ducts, testicular biopsy should always be employed rather than Huhner's older method of testicular puncture. Biopsy also allows one to decide whether the infertility is such that no treatment is likely to have effect, or whether it may be possible to increase its activity by hormone therapy.

Treatment. So little is known of the aetiology of the great majority of cases of infertility that any departure from general health, however trifling it may seem and however little related to the genital organs, must be regarded as being of importance. It would indeed be a wise step to have all sub-fertile patients carefully investigated by a good general physician before any special treatment is carried out. The germinal epithelium is so sensitive to toxins that all infective processes must, if possible, be eliminated. At one time I called attention to the danger of using sulphanilamides on the grounds that they had an adverse effect on spermatogenesis. But, fortunately, this seems to be of a temporary nature, and if infections cannot be got rid of by other means, they should be used. Dr. Wiesner has advocated also the use of an old-time remedy, namely, garlic, either as a fresh infusion of the herb brewed by the patient, or as an extract. I have also had cases of infected semen which have markedly benefited from the use of penicillin.

The diet, habits and mode of life of the patient are also of importance, but I have seen no case of infertility that could be attributed solely to dietetic deficiency. In spite of this I have put patients frequently on wheat germ oil capsules, more especially during the winter months. Recently it has been suggested that because the testes

are very sensitive to heat the taking of prolonged hot baths should be discouraged. There can be no doubt that adverse changes are produced in the seminiferous tubules of animals by a slight increase of heat, and in spite of the fact that we have no direct evidence that hot baths are responsible for human infertility, this suggestion should not be discounted. It is also probable that the substitution of a healthy outdoor life for an indoor occupation would have a beneficial effect, but, unfortunately, it is seldom possible to arrange for this change.

Poor potency may also have to be treated. His wife's ardent desire for a child may render a nervous husband so anxious that not infrequently his potency becomes impaired. Some of the more weakly-sexed husbands seek to derive compensation for infrequent intercourse from the idea that it enriches the quality of the semen, but recent work at Cambridge and elsewhere shows that this is not the case. It has even been suggested that the high incidence of abnormal spermatozoa is more likely to occur when intercourse takes place only at long intervals.

Hormone treatment. Two types of hormones have to be considered, testosterone and anterior pituitary-like hormones. Thyroid has only a minor place in treatment, namely, in comparatively rare cases of hypopituitarism and occasionally, as an adjuvant, when the potency of a middle-aged husband is on the wane. Testosterone may have some action on the testis but its chief use is in stimulating the activity of the accessory glands. Its action on the epididymis is particularly helpful. This organ is not merely a convoluted duct which provides a convenient storage place for spermatozoa. It has its own secretions and has an important function in the bringing of spermatozoa to maturity. This being the case, poor action on its part is probably an important cause of asthenozoospermia. I

am of the opinion that an emulsion of crystalline testosterone is preferable to the usual oily solution, because it provides a deposit from which hormone is slowly absorbed for several days after an intramuscular injection. An injection of an emulsion therefore acts in the same way as the method of implanting pellets advocated by Deanesley and Parkes. The right dosage of emulsion would appear to be about 2 c.cm. weekly. Testosterone should be used in cases of low viability, poor invasive capacity, when potency is weak and when a temporary occlusion of the ducts is suspected. It is unfortunate that no satisfactory and inexpensive anterior pituitary-like hormone is yet available. The preparations of which I have most experience are Gestyl (Organon) and Synapoidin (Parke, Davis). It is very difficult to assess the true value of these preparations since they are often given in the absence of any exact knowledge of the state of the tubules. Because of this, a failure to stimulate spermatogenesis may often be due not so much to an inefficiency of the hormone as to the fact that the tubules are completely degenerated.

As in the case of the ovary, attempts are being made to stimulate the activity of the testis by carefully-regulated doses of X-rays, but more experience of this treatment must be obtained before its value can be assessed.

Surgical treatment. This plays little part in the treatment of male infertility. Since Hagner published his encouraging results interest in the operation of vasoepididymostomy, as a means of overcoming a blocked epididymis, has been renewed. It cannot be said that the results obtained in this country up to date have been satisfactory. Whilst the bringing down of a retained testicle at an early age may undoubtedly safeguard its future spermatogenic function, I have not seen any case in which this operation, when performed on an adult, has

resulted in the appearance of spermatozoa in hitherto sterile semen.

Artificial insemination. This is used when the husband is suffering from incurable impotence and also in certain cases of oligozoospermia and asthenozoospermia. Should the oligozoospermia be associated with any infection of the semen, this must be eliminated or, at any rate, the infecting organism must be identified before insemination is carried out. Otherwise insemination would carry with it some risk of infection to the wife. By employing insemination it can be ensured that some spermatozoa at any rate reach the cervical canal. Before using this method every effort must, of course, have been made to improve, by treatment of the husband, the quality of the semen. But that insemination is a useful sequel to such treatment is shown by the fact that conception has occurred after it with as low a count as 2,000,000. When insemination is used for impotence the husband must not be so sexually abnormal that he is unable to produce semen by masturbation. I know of no means of obtaining semen when the husband is unable to masturbate.

The diagnosis and treatment of infertility in the male has made considerable progress during the last 5 years, but little light has yet been thrown on its causation. In many cases the *genitalia* appear normal, the patient is in excellent general health, he gives no history of having suffered in the past from any of the diseases that are known to have an adverse effect on fertility, and yet when the semen is examined it is found to be of very poor quality. Until more of the factors responsible for infertility are discovered, the treatment of the male, in a childless marriage, cannot be said to be satisfactory.

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Acute Renal Failure Complicating Abortion

BY

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ACUTE renal failure is rare in pregnancy. A study of the literature shows it is still rarer in abortion. The condition seems to be increasing in frequency. During the last 2½ years, 6 cases of acute renal failure complicating abortion occurred in the Gynaecological Department of the Kingston County Hospital, out of a total of 500 abortions admitted. We have also included an interesting case of a multipara who developed acute renal failure following the injection of sterile glycerine into the cord for delayed separation of the placenta.

The following is a synopsis of the cases:

CASE I.

E. J., aged 19, single, primigravida, was admitted to hospital with mild pyrexia and offensive haemorrhagic vaginal discharge. Sulphapyridine, 7 g. and sulphathiazole, 12 g. were administered. Patient's blood was Group A and she was transfused with Group A blood after cross grouping. Three days later vaginal haemorrhage occurred, so digital removal of necrotic offensive placental tissue was performed under intravenous pentothal.

A vaginal smear showed numerous organisms and a culture did not grow haemolytic streptococci. Urinary tests and output were normal on admission. On the 2nd day *Bact. coli* urinary infection developed. Patient was given 19 g. of sulphonamides in all, in 3 days, with alkalis and fluid. By this

time toxic signs (vomiting and dermatitis) developed and the drugs were stopped. A blood-count showed secondary anaemia with leucocytosis. Haematuria appeared on the 6th day after admission. Oliguria set in on the 7th day (30 ounces intake; 2 ounces output in 24 hours). The blood-pressure varied between 120/60 to 130/70. Vomiting became troublesome. The blood-urea rose to 320 mg. per cent. Bilateral ureteric catheterization was performed on the 8th day to exclude renal blockage by sulphathiazole.

Both kidneys were shown to be excreting blood-stained urine, which contained granular casts, leucocytes, red-blood corpuscles, *Bact. coli* in right, none in the left ureteric specimen. A 5 per cent dextrose saline intravenous drip was given. The patient's condition continued to deteriorate, so as a last measure bilateral decapsulation with left nephrostomy was performed. The kidneys were found to be congested. Two days later the urinary output increased temporarily, but coma and death occurred on the 17th day. Autopsy performed by Dr. Rushton revealed grossly enlarged oedematous kidneys with many infarcts. The uterus showed severe infection and contained small fragments of placental tissue.

Dr. Bywaters reported as follows on the histology: "The liver appears normal except for postmortem autolysis and gas bubbles due to intramortem *welchii* infection. The kidneys also show a few gas bubbles, but for the most part they are well preserved and show an appearance similar to those we have found in 'crushing injury', mismatched

transfusion, and septic abortion. There is a marked increase in interstitial oedema with some cellular infiltration, most marked in the boundary zone, and surrounding degenerative changes in the tubules in this area. Some of these tubules are necrotic. The second convoluted tubules show much desquamation; some of the cells show a brown-red pigment, others show mitotic figures of an abnormal type. The collecting tubules contain desquamated cells, partly pigmented and conglomerated masses of brown-red pigment. Some show hyperplasia of the lining and some a mass of necrotic, cellular debris and polymorphs in the lumen. (Case 1: Figs. 1 and 2.) All these appearances have been noted in crushing injury. The clinical account suggests 4 possible causes for the anuria: (1) chemotherapy; (2) mismatched blood-transfusion; (3) haemolysis due to *Cl. welchii*; (4) septic abortion kidney. There is little evidence to incriminate the first three. We would think this renal lesion was the same as we have seen in other cases of septic abortion, and that there was not any evidence of sulphonamide kidney or mismatched transfusion."

CASE 2.

H. A., aged 31, 3para, was admitted as a 12-weeks complete septic abortion. There was a history of vaginal interference by douching with carbolic acid, sickness for 14 days, delivery of the foetus and placenta at home and bleeding for several days.

Previous history: No toxæmia, no kidney disease, malaria 7 years ago. Investigation revealed *Bact. coli* pyelonephritis with suppression of urine and uræmia. Blood urea before transfusion was 300 mg. per cent. There was a severe secondary anaemia. Her blood-pressure was 140/90.

On vaginal examination there was slight bleeding, the uterus was bulky and there was some right-sided parametritis. A blood-transfusion of 2 pints of Group O whole blood was given without reaction, followed by a 5 per cent dextrose-saline drip with high doses of vitamin B and C. The patient's condition was serious; she was drowsy, apathetic and vomiting profusely. Her optic discs showed nothing abnormal. Bleeding from the gums was present. Slight vaginal bleeding was controlled with ergometrine. The urinary output improved on the 2nd day, but the blood-urea values continued to rise for the next 4 days to 370 mg. per cent. The

vomiting improved on the 3rd day and disappeared on the 4th day under therapy which included vitamin B, 40 mg., vitamin C, 1,300 mg. Her general condition rapidly improved and diuresis was normal by the 3rd day. On the 15th day after admission her blood-urea was 25 mg. per cent and her blood-pressure 120/80.

Cystoscopy and bilateral ureteric catheterization showed only cloudy urine coming from the right ureter. The sediments and cultures from the right ureter showed an inflammation of the right kidney without bacterial growth; those from the left ureter a moderate *Bact. coli* infection. An intravenous pyelography did not show any abnormality. The Wassermann and Kahn reactions were negative.

The patient was discharged in a satisfactory condition 23 days after admission. Five months later she was re-admitted for investigation of her kidney function. This revealed normal diuresis, urea concentration test values within normal limits, blood-urea 34 mg. per cent. Urine: deposit showed nothing abnormal. Urine cultures: heavy *B. coli* growth. Treatment with alkalis was adopted.

We concluded, therefore, from the above history and clinical findings that the patient had suppression of urine with uræmia after toxic and secondary *Bact. coli* pyelonephritis, following self-induced septic abortion in the 3rd month of pregnancy.

CASE 3.

Ch. E., aged 45, married, 11-gravida, admitted as an emergency on May 7th, 1943, with an inevitable abortion of 24 weeks. She had not had any antenatal care.

Previous history: 7 normal deliveries, 5 full-time babies, alive; 2 children died of prematurity. Recently had noticed oedema, and some years ago had pyelitis. Three abortions, the last 2 at Kingston Hospital in 1938, 24 weeks, spontaneous, no toxæmia; 1939, 24 weeks, spontaneous, no toxæmia.

Present history: first vaginal bleeding on morning of admission associated with abdominal pain. Passed urine normally at home, had no swelling of the ankles or face and felt well.

General condition on admission: Pale and moderately shocked. Optic discs normal, blood-pressure 120/70; temperature 97.4°F.; urine, trace albumin. Fundus, 26 weeks, uterus tender.

Vaginal examination, slight loss; cervix, 1 finger dilated, uterus contracting.

Conservative treatment was adopted. Blood-transfusion by drip, 2 pints Group O blood, not cross-matched, no reaction.

The following day, May 8th, a foetus, freshly dead, 24 weeks, was expelled with an incomplete placenta. The placenta showed widely spread, fresh, red infarcts and a large recent clot covering one third of the organ. In view of free loss, dilatation and curettage were performed under 0.5 g. pentothal intravenous anaesthesia. Remnants of placenta were removed and the haemorrhage was controlled. Three pints Group O blood were transfused by drip without incident. Sulphathiazole, 1 g., t.d.s. was given for prophylactic reasons with sodium citrate, gr. 30, t.d.s. Patient was fairly well and passed urine. On May 9th, oliguria was noticed in the evening. The patient's condition seemed satisfactory. Sulphathiazole was stopped after a total dose of 4 g. On May 10th, a sudden eclamptic convulsion occurred, lasting 3 minutes. Later in the day catheterization revealed anuria. Patient's general condition was now poor, and her blood-pressure had risen to 200/120. Blood examination showed severe secondary anaemia with leucocytosis and a blood-urea of 124 mg. per cent. Further serological investigations by Dr. Loutit showed that the transfused blood was Group Rh positive and the patient's blood was Group Rh positive also. The serum did not contain any atypical agglutinins. The Van den Bergh blood-bilirubin test was direct and indirect negative. This negative reaction within 36 hours after the last blood-transfusion showed that there was little likelihood of an appreciable haemolysis of the transfused blood. Treatment consisted of 40 c.cm., 30 per cent intravenous dextrose and by drip in the form of a 5 per cent solution.

Both ureters were catheterized, but only a few c.cm. of blood-stained urine escaped. A diagnosis of symmetrical cortical necrosis of the kidneys was therefore made.

As the suppression of urine with signs of uraemia did not improve, Mr. Jennings Marshall performed a bilateral decapsulation with right-sided nephrostomy under local anaesthesia. Both kidneys appeared congested and the capsule stripped easily. There were multiple small haemorrhages over the

surface. The patient died 12 hours later in uraemic coma.

Postmortem examination (Dr. Rushton) disclosed a left-sided pleurisy and left ventricular hypertrophy with mild atheroma of the aorta and oedema of the brain. The left and right kidneys showed extensive subcapsular haemorrhages with irregular wedge-shaped multiple necrotic areas in the cortex. The liver was markedly degenerated. The uterus did not show any abnormality. Dr. Loutit, who submitted the sections to Dr. W. Woods of the Pathological Department of the London Hospital, and Professor Ellis of the University of Oxford, sent us the following reports on the specimen from the autopsy:

"One portion of the kidney: Large wedge-shaped, dark purplish-red area of subcapsular haemorrhage. Irregular, more or less wedge-shaped, multiple patches in cortex, separated by dark areas showing radial striation and separated from the medulla by similar striated dark zone. Vessels not unduly prominent. Several other portions of the kidney showing similar picture. Portion of arterial wall: Showing faint, linear streaks in intima and oedematous adventitia. Portion of the liver: Well-marked lobular pattern, the periphery of the lobules being putty colour and the centres pale brown. Portion of left ventricle: Showing pale, firm musculature. Kidneys: The histological picture in the sections of the two kidneys is similar. The capsule is replaced by a layer of recent blood-clot. The cortex is divided by bands of haemorrhage into roughly wedge-shaped areas which show almost complete coagulative necrosis (Figs. 3 and 4) the ghosts of glomeruli and tubules being well visualized, but individual cells are not recognizable and nuclei, where visible, are very pale, swollen and structureless or fragmented and pyknotic. In the haemorrhagic areas the parenchyma is also necrotic, the interstitial tissue being markedly infiltrated with polymorphonuclear leucocytes, lymphocytes and mononuclear cells as well as red-blood cells. The tubules of the medulla show degenerative changes, karyolysis being marked; they contain hyaline, granular and occasional cellular, and blood-casts (Fig. 5). There are also a few small interstitial medullary haemorrhages. In the intermediate zone is a narrow band of cortical tissue in which the cells of the tubules are not completely necrosed though the nuclei are markedly pale. The

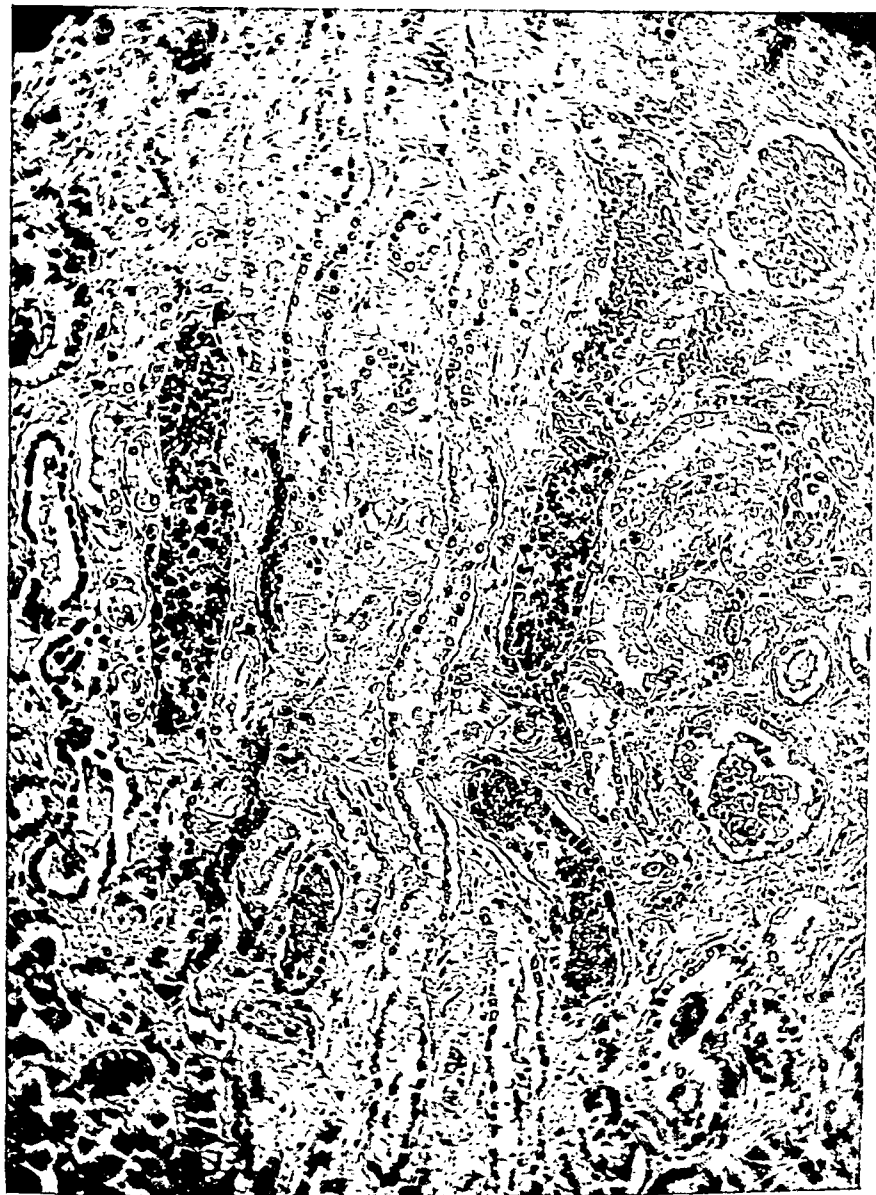


FIG. 1.

Photomicrograph of a kidney section in Case 1 (abortion kidney) showing interstitial oedema, cellular infiltration and degenerative changes in the tubules. (Magnification $\times 160$)



FIG. 2.
Photomicrograph of an "abortion kidney" showing high power magnification ($\times 220$) of an area with pigmented ribbon and granular casts.



FIG. 3.

Photomicrograph of a kidney section in Case 3, showing almost complete
(Magnification $\times 65$)
coagulative necrosis.

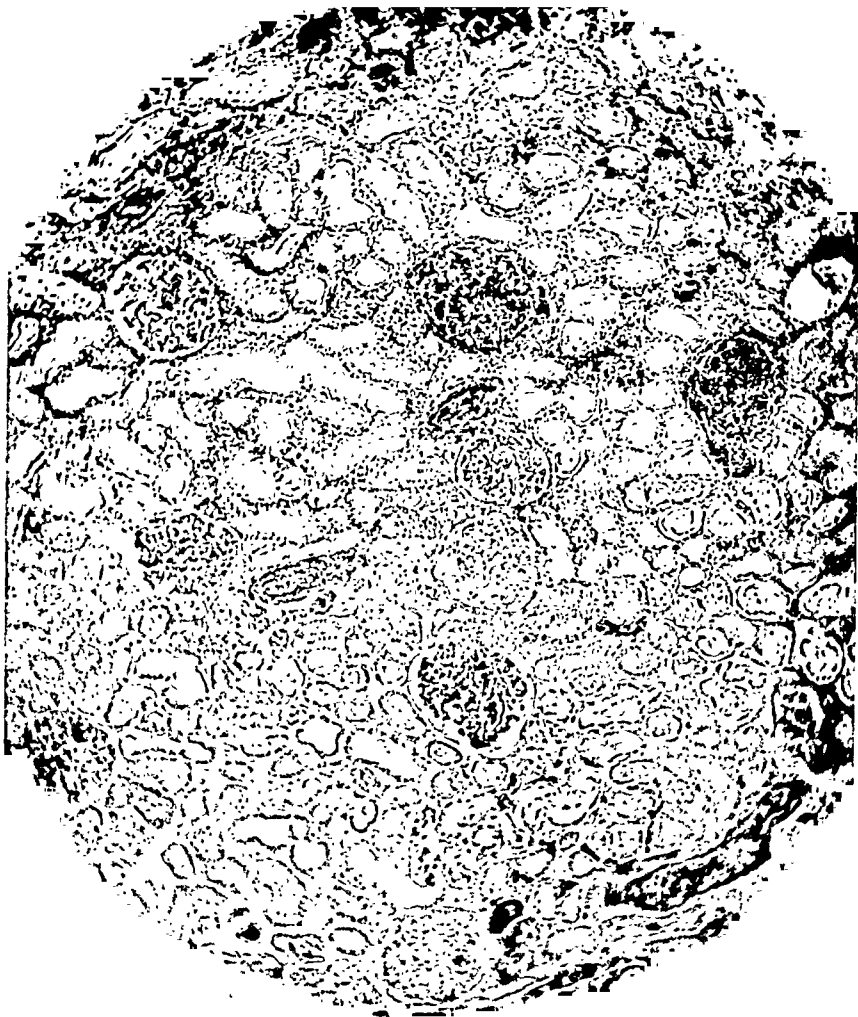


FIG. 4.

Photomicrograph of a kidney section in Case 3, showing the ghosts of glomeruli and tubules.
(Magnification $\times 60$)

s. & o.



FIG. 5.

Photomicrograph from section of kidney in Case 3, showing the degenerative changes of the tubules and thrombosis of an interlobular artery.

(Magnification $\times 75$)

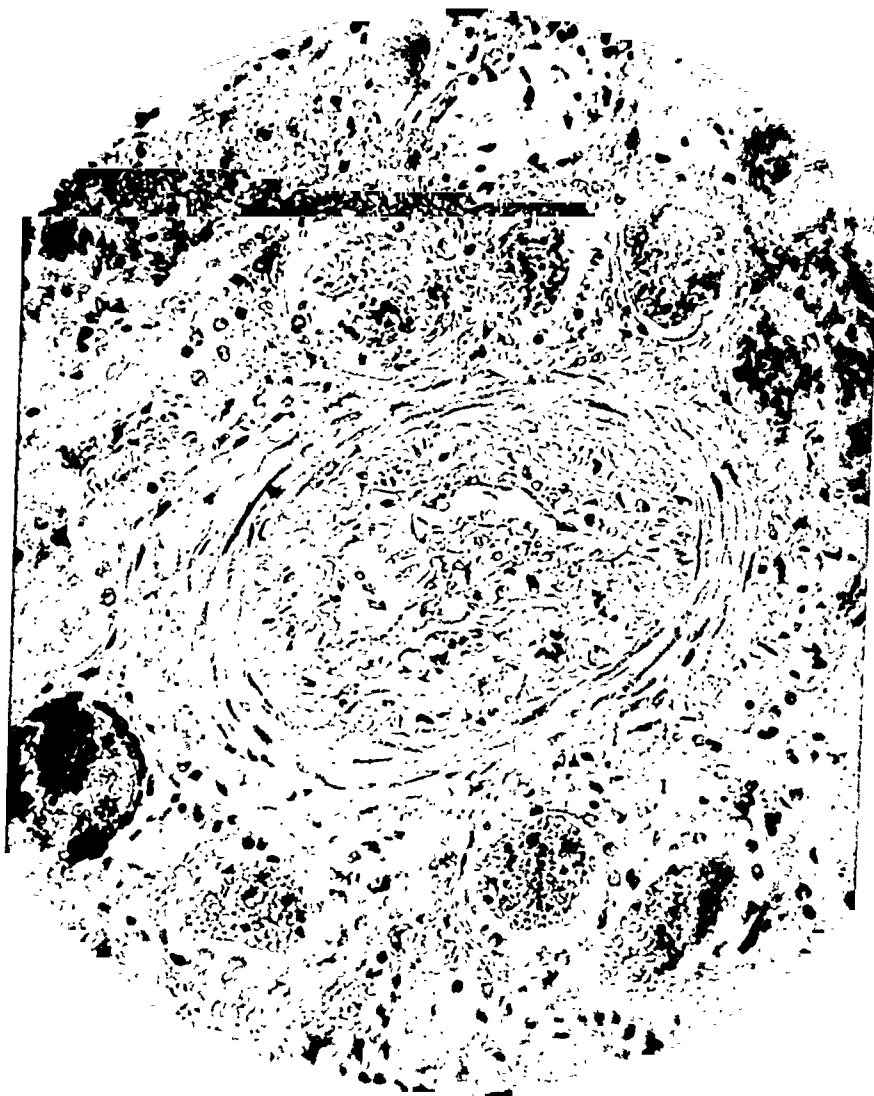


FIG. 6.

Photomicrograph of a kidney section in Case 3 showing intravascular thrombosis.
(Magnification $\times 270$)



FIG. 7.

Photomicrograph of a liver section in Case 3.

(Magnification $\times 130$)

s. & o.



CASE 3, FIG. 4.

Photomicrograph of a kidney section in Case 3 of bilateral cortical necrosis
in abortion.

(Magnification $\times 130$)

glomeruli here show focal necroses, adhesions to Bowman's capsule and polymorphonuclear infiltration. Some show acute degeneration and necrosis of the afferent arterioles, the almost structureless swollen arteriolar wall staining positively for fibrin. The interlobular arteries of the cortex show similar fibrinoid degeneration of the intima and necrosis of the whole arterial wall; there is no perivascular cuffing. Intravascular thrombi are seen in many arteries (Fig. 6). Thrombi are also seen in some of the arcuate arteries of the intermediate zone, but apart from some splitting of the internal elastic laminae the coats of these vessels appear normal.

Liver: A section of the liver (Fig. 7) shows the cells of the parenchyma to be markedly degenerate, with pale staining, granular and faintly vacuolar cytoplasm. Sudanophil fat is not demonstrable. The nuclei are markedly swollen and show loss of chromatin. The cells appear to be more or less equally affected throughout the lobules. The cells in the centres of lobules contain a fairly large amount of fine, yellowish-brown pigment. In many of the portal canals the portal vein is seen to be filled with a fine reticulum taking a positive fibrin stain and enmeshing a variable number of red cells. **Heart:** The myocardial fibres appear of average size, a few of the nuclei are pale and vesicular. A large branch of the coronary artery appears normal."

From a review of the clinical features of this case it is evident that the patient, an elderly multipara, had some preceding renal involvement and an abortion taint in her history.

CASE 4.

J. E., aged 31, married, 2-para; was admitted after 14 weeks amenorrhoea as a septic incomplete abortion.

On admission the patient was anaemic and shocked, with blood-pressure 110/70; pulse-rate 120, pyrexia 100.6°F., haemoglobin 32 per cent, micturition normal, and the uterus enlarged to the size of a 14 weeks' pregnancy. She gave a history of having used slippery elm on herself to bring on abortion. Swabs and smears from the vagina showed no haemolytic streptococci.

An immediate blood-transfusion of 2 pints Group O whole blood was given by the drip method.

Sulphapyridine, 1 g. 4-hourly with sodium citrate, gr. 30 t.d.s. and pituitrin, 3 units b.d. were

given. The treatment was conservative for 14 days in view of the obvious signs of uterine infection. Three further blood-transfusions, by drip, with 2 pints of Group O whole blood after cross-grouping (Group O) were given to treat the marked secondary anaemia. Only after the 4th blood-transfusion (2 pints, Group O cells) did the patient react with headaches, right loin pain and slight jaundice. On the 15th day after her admission dilatation and curettage was performed after the administration of 0.4 g. sodium pentothal. The sulphonamides had been discontinued several days before, after a total dose of 26 g.

On the 17th day after admission, 3 days after her last transfusion, the patient showed almost complete suppression of urine and severe jaundice. Her blood-urea at this stage was 205 mg. per cent. Serological investigations by Dr. Loutit proved that the urinary suppression in this patient was due to the transfusion of Rh incompatible blood. The fact that the recipient was Rh negative and that her serum 3 days after the transfusion contained an antibody which agglutinated both random Rh positive erythrocytes and erythrocytes transfused 3 days previously, suggests that the Rh antibody developed as a result of the immune process from the 3 previous transfusions and was the antibody responsible for the haemolytic reactions. A bilateral splanchnic block, with 1:2000 Amethocaine, was performed and a 5 per cent dextrose-saline drip was set up. The patient responded very satisfactorily. Her diuresis improved remarkably (5 ounces after the block) and her severe anaemia was treated with a further blood-transfusion of 2 pints Group O Rh negative cells and whole blood, without incident. The further course of the patient was uneventful and she made a perfect recovery. She was discharged 8 weeks after admission and had a blood-urea of 25 mg. per cent. The patient did not attend for follow-up examination.

CASE 5.

S. E., aged 37, married, 3-gravida; admitted as an emergency without previous antenatal care on October 4th, 1943, complaining of moderate vaginal loss.

Previous history: Three normal deliveries; the last was in 1940, twins and toxæmia; the first was in 1930. No abortions. She had no history of any

disease. One month before the patient fell and sustained a superficial wound on her left leg which healed. At that time she had a slight show which disappeared on resting.

Present pregnancy: For 1 month she had noticed occasional swelling of her legs, also headaches, which were relieved by aspirin. On the day of admission a sudden heavy loss occurred, accompanied by abdominal pains. Foetal movements were felt until the day before admission. On general examination the patient was pale, but her condition was satisfactory, her blood-pressure 110/70, temperature 101.2°F., pulse-rate 93; heart, lungs, and central nervous system were normal. Her uterus was enlarged to about the size of a 24 weeks' pregnancy, and was contracting. No foetal heart could be heard. On vaginal examination the cervix admitted 1 finger.

A diagnosis of septic inevitable abortion was made.

On catheterization: Three ounces of deeply blood-stained urine were withdrawn. A vaginal swab and smear were negative. Sodium citrate, gr. 30, 4-hourly and sulphathiazole, 1 g., t.d.s.; pitocin 3 units, b.d., Benerva 5 mg. intramuscularly were ordered and a self-retaining catheter was inserted.

On October 5th the patient was vomiting and complained of abdominal pains due to uterine contractions. There was also moderate bleeding. Blood-pressure 110/70, temperature 100.8°F., pulse-rate 110. Only 3 ounces of deeply blood-stained urine were collected from the bladder in 24 hours. Urine analysis showed blood pigments and debris only. Culture revealed no growth. Patient's blood-urea was 25 mg. per cent and her haemoglobin (Haldane) 68 per cent. Sulphathiazole was discontinued after a total dose of 4 g. 40 c.cm. of 30 per cent dextrose was given intravenously, followed by 5 per cent dextrose-saline by intravenous drip. At 10 p.m. the patient delivered herself of a freshly macerated foetus of about 24 weeks, with a normal-looking placenta and a few old clots. The total blood-loss was small and the uterus contracted well after 5 units of pitocin. A slight rigor and vomiting occurred after the delivery. October 6th: Severe oliguria (2½ ounces) continued throughout the day. The urine was dark red in colour. The blood-urea was 72 mg. per cent. Copious vomiting persisted. October 7th: Condition of patient deteriorating. Vomiting still constant and severe;

drowsiness developing. Urinary output dropped to 5½ drachms in 24 hours. Tests showed that the patient was Group O Rh negative. An X-ray of the kidneys revealed nothing abnormal. To effect diuresis a bilateral splanchnic block with 70 c.cm. ½ per cent procaine was performed. October 8th: Suppression of urine (1 ounce) continued. On spectroscopic examination the dark urine showed oxyhaemoglobin but no methaemoglobin. Patient complained of drowsiness, headaches and spots before the eyes. She vomited 24 ounces during the day. Optic discs: no papilloedema. A complete blood-count showed haemoglobin 60 per cent, 3,740,000 red cells, 10,800 leucocytes. A cystoscopy and bilateral ureteric catheterization were performed and it was found that the right ureter passed only very little blood-stained urine, the left nothing. October 9th: Oedema of the legs appeared. Patient's condition was uraemic. Suppression of the urine continued; only 1 ounce in 24 hours was passed. October 10th: 3.5 ounces of blood-stained urine was passed, blood-urea 75 mg. per cent. October 12th: Patient seemed moribund with respiration laboured and profuse vomiting; she was irrational and drowsy; her blood-pressure was 130/70. The urinary output was 2.4 ounces and on analysis showed many pus cells and red cells, no casts, a few renal epithelial cells, no growth, no tubercle bacilli. Another bilateral splanchnic block was performed; this time with 60 c.cm. of 1:2000 Anethaine (Amethocaine) Glaxo. October 13th: Less vomiting (15 ounces), passed 6.4 ounces of blood-stained urine. October 14th: Marked improvement in general condition. Vomited only 3 ounces. Passed 17½ ounces of clear urine. Blood-pressure 130/70. Optic discs normal. October 15th: Normal mental condition, no uraemic symptoms. Passed 36 ounces of urine during the day. October 16th: Patient felt very well. Blood-pressure 130/70; blood-urea 180 mg. per cent. Urinary output increased to 75 ounces of cloudy urine. Analysis showed pus and red cells and heavy growth of *B. coli*. Although her haemoglobin was only 60 per cent, a blood-transfusion was not given in view of the Rh negative test, to avoid possible reaction in the damaged kidneys. During the following days her condition improved steadily. The treatment consisted of large doses of iron, vitamins C and B₁. Her Wassermann and Kahn reactions were negative.

It is an interesting fact that from November 5th the patient developed hypertension. The blood-pressure rose from 130/96 to 160/90; the urine was clear, the output was within normal limits and the blood-urea was 30 mg. per cent. She was discharged on November 27th in excellent health, after being in hospital for 56 days. We were unable to see her for follow-up examinations, but from a recent letter we assume that she is getting on well.

This is one of the rare cases of "symmetrical cortical necrosis" of the kidneys with recovery.

CASE 6.

K. L., aged 36, primigravida, admitted August 8th, 1944, with septic incomplete abortion of 20 weeks. There was nothing of note in her previous history.

Present history: Patient stated that 10 days ago rupture of the membranes occurred. She did not interfere with herself and did not see any foetus come away. She had passed urine normally.

On admission: General condition was satisfactory; urine normal; temperature 100°F.; pulse-rate 106; blood-pressure 100/70; uterus the size of 20 weeks; few small fibroids also palpable in fundus. Sulphapyridine, 1 g. 4-hourly with alkalis and abundant fluids were ordered. August 9th: Digital removal of the placenta and curettage was performed, accompanied by free bleeding which was controlled by intrauterine injection of pitocin, ergometrine and a hot proflavine douche. A catheter specimen showed nothing on culture. A vaginal swab and smear was negative; blood-transfusion was avoided until Rh factor was determined. On the next day pyrexia 101.6°F.; pulse-rate 120; general examination discovered nothing abnormal. August 11th: The lower abdomen was tender and patient complained of a sore throat. Micturition was normal and painless. On August 12th she vomited twice and felt ill. Sulphapyridine was now replaced by the less toxic Sulphamezathine. On the 13th, oliguria developed for the first time, 12 ounces in 24 hours. The urine was not blood-stained. Sulphonamides were discontinued after a total dose of 21 g. After this diuresis improved speedily, but her vomiting continued on the 14th. Oedema of the legs became apparent and slight right papillo-oedema was found. Her blood-pressure was 96/40. A catheter specimen did not reveal any abnormality.

Her blood-urea was 42 mg. per cent and her blood Group O Rh positive. The full blood-count revealed a moderate secondary anaemia and leucocytosis, and it was therefore unlikely that the renal failure was due to the sulphonamides. She was treated by intravenous 5 per cent dextrose-saline and alkaline therapy and she made a speedy recovery.

The patient's condition was of interest in so far as it probably indicated mild, early kidney damage due to a septic abortion. One month later a general examination did not reveal anything abnormal and an intravenous pyelography was normal.

CASE 7.

N. T., aged 28, married, 2-para. After normal antenatal period admitted on April 24th, 1935, in labour to the City of London Maternity Hospital. A normal delivery of a 6 pounds 7 ounces girl occurred but the placenta was retained. Four hours after the end of the 2nd stage 200 c.cm. sterile glycerine were injected into the umbilical cord without effect. The patient complained of headache and had a slight loss of blood *per vaginam* following the injection. April 26th: Placenta still retained. Patient vomited once and was jaundiced. Temperature 98.8°F., pulse-rate 92. A glucose-saline infusion was given. On manual removal of the placenta a contraction ring and a small interstitial fibroid were found. At the end of the operation the patient was very shocked; pulse-rate 130, skin cold and clammy. She recovered with warmth, etc. April 27th: Vomiting marked; oliguria now present; urine port-wine coloured (1½ ounces), which on microscopy showed clumps of red cells. Potassium citrate given. April 28th: Complete suppression of urine developed. Treatment consisted of saline and sodium bicarbonate transfusion. One rigor occurred. April 29th: Blood-urea 120 mg. per cent. Blood-sugar 0.1 per cent. Van den Bergh: direct negative, indirect positive. Haemoglobin, 35 per cent; red cells, 1,900,000; white cells, 13,700; polymorphs, 85 per cent; lymphocytes, 13 per cent, mononuclears, 2 per cent. Catheter specimen of urine: no pus, blood or casts, some diptheroids only. Later catheter specimens: pus, few red cells, no casts, no leucin or tyrocin or bile, pH 8. Mixtures of organisms, methaemoglobin present. Passed 1 to 2 ounces urine into bed. Blood-pressure 100/65. Bowels opened. April 30th: Blood-urea

134 mg. per cent, no vomiting, less jaundiced. There was a faint trace of albumin. The patient was drinking well. Her abdomen was distended but not tender. May 1st: Oedema of the face appeared, anuria and uraemic smell were also present; the bowels were loosely open. Intravenous saline with dextrose administered. The patient passed 3 ounces of urine, blood-urea 127 mg. per cent. May 2nd: Haemoglobin, 40 per cent; red cells, 2,500,000; colour index 0.8; anuria, bowels open. May 3rd: Rigor, oedema of the legs and face; right lung congested, cardiac stimulants, glucose 30 per cent, 50 c.cm. given; blood-pressure 140/75; blood-urea 241 mg. per cent; haemoglobin 38 per cent; patient developing acute mania—morphine and hyoscine were ordered. There was still suppression of urine; plenty of fluids taken by mouth. May 4th: Definite improvement, wet bed twice. Chest still congested and no movement of the bowels; blood-pressure 150/85, caffeine given. May 5th: Passed urine 3 times (8 ounces) and one stool, rigor, temperature 100.2°F., pulse-rate 140, irrational. May 6th: Patient very ill—gasping. May 7th: Some improvement noted. General oedema now present, no jaundice, cyanosis marked. Patient was given cardiac stimulants, magnesium sulphate, calomel. Output of urine was 25 ounces. May 8th: Urine: specific gravity 1012, pH 8.5, cloud of albumin, no acetone. Blood-urea 298 mg. per cent. Excellent urine output, cough improved, no headaches, clean tongue, oedema nearly gone. May 9th: Urine 60 ounces, blood-pressure 135/70. Abdomen still enlarged, ascites present. Uterus involuting slowly, haemoglobin 52 per cent, white cells 16,000, red cells 3,050,000. May 10th: 130 ounces urine in 24 hours. Excellent condition. May 11th: 127 ounces urine. Blood urea 270 mg. per cent. May 12th: 110 ounces of urine. May 13th: 120 ounces of urine. Blood-urea 20 mg. per cent. May 15th: Urine specific gravity 1014, pH 5. No sugar, no acetone, cloud of albumin. May 16th: Haemoglobin 54 per cent, urine output well maintained. May 20th: Catheter specimen: heavy growth of *B. coli*, no blood, no casts. May 21st: blood-urea 60 mg. per cent, patient on iron and potassium citrate. May 31st: Blood-urea 28 mg. per cent. June 3rd: Blood-pressure 115/75. June 7th: Haemoglobin 68 per cent, red cells 3,700,000; white cells 9,000. June 12th: The patient was discharged.

Postnatal examination. September 24th, 1935: Patient was very well, blood-urea 28 mg. per cent, blood-pressure 135/70, urine clear, optic discs: faint blurring, micturition normal, no anaemia, menstrual periods 3-5/31. June 21st, 1936: Blood-pressure 128/80; urine clear; occasional headaches; otherwise quite well.

This case of acute suppression occurred after delivery at term in a healthy multipara. Apparently the origin of the trouble was the sterile glycerine given for the retention of the placenta. Clinically she was a case of bilateral cortical necrosis. A study of the available literature has failed to reveal a similar case.

REVIEW OF THE LITERATURE ON RENAL FAILURE FOLLOWING ABORTION.

Symmetrical cortical necrosis of the kidneys was first reported by Juhel-Renoy¹ in 1886 in France, and by Bradford and Lawrence² in 1898 in England. Torrens³ described a 29-year-old patient with a 4 months' miscarriage followed by anuria. There was mild pyrexia but no convulsions. Postmortem examination disclosed a massive infarction of the entire cortex of both kidneys and thrombosis of the renal and ovarian vessels. Jardine and Kennedy⁴ reported a 23-year-old primigravida who for several weeks before admission had had oedema, vomiting, failure of vision and headaches. She aborted at 4½ months, when her urine was solid with albumin. She then had one eclamptic fit followed by 2 days anuria. On postmortem examination the liver changes were not typical of eclampsia. The kidneys showed patchy cortical necrosis. Thrombosis was very infrequent. White's⁵ cases of puerperal anuria with recovery were not regarded by Gibberd³⁰ as typical of symmetrical cortical necrosis according to the published biopsy which was taken after decapsulation. Cruickshank⁶ in 1923 described a 10-gravida of 33 with a 5 months' abortion who died after 4 days' oliguria and 5 days

anuria. Postmortem examination showed symmetrical cortical necrosis of the kidneys and widespread thrombosis of the smaller renal arteries.

Fraenkel⁷ encountered haemoglobin casts in postabortal gas-gangrene septicaemia and blamed the low pressure due to the illness for the diminished secretion and the haemoglobin casts. Carson and Rockwood⁸ reported a case of a 36-year-old woman with a hypertension of 200/130 and anuria in an abortion of 24 weeks. No other signs of toxæmia, no convulsions, no abruptio placentae were present. A symmetrical cortical necrosis of the kidneys was found on postmortem examination. Seitz⁹ reported 3 cases in which quinine, given in 3 doses of 0.5 g. (gr. $7\frac{1}{2}$) to induce abortion in early pregnancy, was followed by suppression of urine with fatal haemoglobinuria and methaemoglobinuria. No histologic changes were described. Kutz and Traugott¹⁰ reported the same picture. Scriver and Oertel¹¹ examined carefully 2 abortions with anuria. Both cases, 34 and 33 years old, aborted with accidental haemorrhage at 24 weeks without any signs of toxæmia apart from hypertension. There were no fits. The kidneys in both cases were typical of cortical necrosis. Petri¹² published a case in early pregnancy with oliguria, haemoglobinuria and methaemoglobinuria after barbitol and 1 g. quinine each day for 3 days. Microscopically the kidneys showed abundant haemoglobin casts in the glomeruli and in the convoluted tubules. The tubules did not show any epithelial changes. The paper by Kellar and Arnott¹³ in 1932 deserves special reference. Their case (1) was a 26-year-old 1-para, whose pregnancy in the 5th month, with moderate signs of toxæmia and suppression of urine for a fortnight at home, was terminated by an abdominal hysterotomy. Death in coma occurred after 18 days anuria. Their case (3) was aged

29, 2-para, pre-eclampsia, blood-pressure 158/100, urine solid with albumin, oedema and oliguria. After concealed accidental haemorrhage, pregnancy was terminated at 5 months. Almost complete anuria followed for 7 days. Ureteric catheterization and decapsulation failed to relieve the suppression of urine and the patient died. Both cases showed evidence of toxæmia; the second, premature separation of the placenta. Pathological examination of the kidneys showed classical cortical necrosis with a predominating selective vascular element. As the probable mechanism of thrombosis they assume an "endotheliolytic toxin" (Leith Murray) manufactured in the liver or placenta. Warner and Hibbitts¹⁴ in 1932 reported a multipara, 26 years old, with a 6 months' miscarriage and typical signs of abruptio placentae and severe pre-eclampsia; blood-pressure 180/110; albuminuria, oliguria, oedema, non-protein nitrogen 55 mg. per cent. Spontaneous abortion of a dead foetus occurred with typical infarcted placenta and large blood clot. After 3 days of complete suppression of urine, death in uraemia supervened. In their case, also, the renal cortical changes showed distribution on a circulatory basis. They consider that vasoparesis with stasis and thrombosis are the aetiological factors of necrosis. Jeddloh¹⁵ published the first article on renal pathology after septic abortion, following 2 cases of criminal attempts at termination of pregnancy in the 4th and 3rd months. In the first case the uterus and gut were perforated. Eight days after hysterectomy the patient died of anuria. The postmortem examination showed cortical necrosis of the kidneys with severe inflammatory reaction. Case 2 died of anuria 4 days after an attempted criminal abortion completed by dilatation and curettage. Again a symmetrical renal cortical necrosis was found and Jeddloh observed inflammatory

changes in the glomeruli, first convoluted tubules and interstitial tissue. Jeddeloh cited the only previously recorded cases of this renal condition from the German literature: Hertzog,¹⁶ who described bilateral necrosis of the renal cortex following a purulent peritonitis in a girl of 10 years, and Furtwängler¹⁷ after a severe accident. Lubarsch,¹⁸ and Fahr,¹⁹ described similar pictures in toxæmia of pregnancy.

Bowes²⁰ described a 6 months' miscarriage in a patient of 32 years, with complete anuria, toxæmia and no convulsions or antepartum hæmorrhage. Johnstone²¹ thought that the loss of blood leads to slowing of circulation and thrombosis, otherwise it would be difficult to understand the selective action of "endothelial" toxins in cortical necrosis. Ash²² again referred to the prolonged vasospasm as the cause for the occlusion and called symmetrical cortical necrosis "angioneurotic anuria."

In a clinico-pathological study in 1934 one of us (W.S.)²³ reported hæmoglobinuria and methaemoglobinuria with suppression of urine in a patient 7 months pregnant with toxæmia of pregnancy. The urine was burgundy-coloured and contained many hæmoglobin casts, granular casts and red cells. A quinine intoxication was diagnosed and the patient died in coma without convulsions. The postmortem examination showed typical eclamptic liver changes, a cerebral hæmorrhage and severe degeneration of the kidney tubules in the absence of blockage. In 3.572 g. weight of different organs, 0.3 g. (5 gr.) of quinine could be recovered and it was suggested that in this case of "eclampsia without convulsions" quinine taken by the patient caused a paroxysmal destruction of erythrocytes.

In the light of more recent research on the mechanism of the production of the renal lesion in hæmolytic conditions, the case is both rare and interesting. It demonstrates

severe toxic tubular damage without mechanical blockage of the tubular lumina by the altered blood pigments. The primary mechanism of the renal lesion was probably the toxæmia with its hæmolytic and necrosing factors aggravated by the hæmolytic action of quinine causing massive hæmoglobinuria and methaemoglobinuria. The findings seem to support the view that simple mechanical blockage of the tubules by blood casts is not responsible for the anuria in fatal cases of hæmoglobinuria in pregnancy. The exact nature of quinine hæmolysis is not understood.

Nocht and Kikuth²⁴ have shown that very small quantities of quinine may facilitate amboceptor hæmolysis in animal experiments. Donath and Landsteiner²⁵ found that during pregnancy autohæmolysins are formed by a gradual disintegration of a large number of erythrocytes. The only report in the American literature of fatal hæmoglobinuric kidney damage due to quinine in an abortion comes from Terplan and Javert.²⁶ Their case was a 41-year-old woman in the 3rd month of pregnancy who had taken quinine, estimated as 100 gr. (6.5 g.). She developed vaginal bleeding, oliguria, hæmoglobinuria, and died in uræmic coma. Microscopically the kidneys showed marked distension of the tubular system brought about by masses of hæmoglobin casts associated with definite focal inflammatory lesions; 3 gr. (0.2 g.) of quinine were recovered from the liver. The authors stressed the fact of special susceptibility to quinine hæmolysis in pregnancy. Terplan and Javert commenting further on the renal failure, state that quinine does not exert a direct action on the kidneys and is excreted by the gastro-intestinal tract and the kidneys very shortly after intake. When the hæmoglobin, following hæmolysis, reaches a sufficient level in the blood it is excreted by the kidneys and hæmoglobinuria results. They regard the

kidney damage as due to the accumulation of haemoglobin in the tubules, with mechanical obstruction of the outflow of secreted urine.

Reyna²⁷ published a typical case of pre-eclampsia and placenta praevia in a 24 weeks' miscarriage. The blood pressure was 245/180. Death in coma followed 3 days' anuria. The renal pathology showed symmetrical cortical necrosis and the liver showed eclamptic changes. Kernau²⁸ reported 4 cases of gas-gangrene after abortion with oliguria and anuria. All cases showed severe nephrosis and haemoglobinuria with casts. It is interesting here to note that Kernau cites a publication by Wolff²⁹ who published, from the war of 1914-18, 100 cases of wound gas-gangrene, in 38 of which the author found similar kidney changes.

Gibberd³⁰ who reported 2 cases of symmetrical cortical necrosis in late pregnancy with recovery, pointed out the importance of making a clinical diagnosis of symmetrical cortical necrosis and not abandoning it in the fortunate event of the patient's recovery, for that of "suppression of urine". He remarked on the pathognomonic initial secretion of a small amount of bloodstained urine in the presence of the other typical clinical features in cases of concealed accidental haemorrhage.

The cases of Crook,³¹ Scriver and Oertel,³¹ Gibberd,³⁰ Dieckmann,³² Madding, Binger and Hunt,³³ Dingle,³⁴ Adam³⁵ our cases 5 and 7 are, so far as we could detect in the available published literature, the only clinically diagnosed cases of symmetrical cortical necrosis in pregnancy with recovery. Volk's³⁶ case is an abortion of 6 months with premature separation of the placenta, toxæmia and anuria of 5 days duration. Rubin and Petru's³⁷ case was another 24 weeks abortion with anuria and no signs of accidental haemorrhage and toxæmia.

In 1941 Duff and Moore,³⁸ pathologists at McGill University, Montreal, gave an excellent review of the whole subject of symmetrical cortical necrosis of the kidneys, including the previous survey by Ash in 1933. They analysed 71 cases of bilateral cortical necrosis and divided them into 2 groups:

(1) Forty-eight cases occurring in pregnancy.

(2) Twenty-three cases occurring apart from pregnancy.

Two-thirds of the pregnancy series terminated in abortion or premature labour. In 21 cases there was antepartum haemorrhage and in 7 cases, pre-eclampsia.

Only 1 out of the 12 authors, in the 15 cases of cortical necrosis in abortion, mentions convulsions in the clinical features. Jardine and Kennedy's case of a 4½ months abortion with toxæmia and anuria had one eclamptic fit and the post-mortem examination did not show typical eclamptic changes in the liver.

In Duff and Moore's 15 collected cases of cortical necrosis, the abortion was associated:

- in 4 cases with toxæmia;
- in 6 cases with accidental haemorrhage;
- in 3 cases with infection;
- in 2 cases with no manifest clinical conditions.

The most puzzling feature of symmetrical cortical necrosis in abortion is its rarity compared with the frequency of its apparent exciting causes, such as retroplacental haemorrhage, shock and infection. Duff and Moore described the pathology of the kidneys very clearly. These authors agree as to the localisation of the vascular changes in the intralobular arteries and efferent arterioles of the glomeruli and they also agree to the virtual exclusion of arteries of larger size. The aetiology of the condition is still in doubt although it is generally agreed that symmetrical cortical necrosis

is the result of ischaemia caused by obstruction of the terminal cortical arteries and arterioles. The usual stages seem to be vasospasm, vasoparalysis, stasis, thrombosis and necrosis.

Dawbarn and Williams³⁹ noticed severe oliguria with passing of black urine in gas-gangrene infection of the uterus.

In some cases in which the *Cl. welchii* infection had been successfully controlled, Adey⁴⁰ considered that anuria caused the death of the patients. He pointed out that the kidney changes were due to the direct action of the toxin and to the disintegration of haemoglobin in the tubules.

In the recent excellent review on *Cl. welchii* gas-gangrene infection of the uterus by Rendle-Short⁴¹ we searched the 4 reported postabortal cases for evidence of renal failure.

In the 3 Bristol cases, Case 1 procured an abortion by injecting cow's urine into the uterus. The patient showed only a little bloodstained urine on catheterization and the postmortem examination of the kidneys was not mentioned.

Case 3 (1942) when 3½ to 4 months pregnant, syringed with soap and water and later passed acid, port-wine-coloured urine which was not noticeably reduced in quantity. The deposit showed blood pigment, debris, bloodcasts and *Cl. welchii* in large numbers.

Rendle-Short discussed the urine in a typical case of gas-gangrene but we are unable to find notes of any renal investigations or on renal pathology elucidating the renal failure in postabortal gas-gangrene cases. In future it would be of value to have full reports on diuresis and renal investigations in this particular field of renal failure.

A very interesting contribution to the problem of postabortive anuria came from a group of South American investigators. Chabanier, Lobo Onell, Michon and Lelu⁴² gave a very thorough study of the decapsu-

lated kidneys in a case of criminal abortion. The patient's main symptoms were, apart from haematuria and anuria, an accentuated hypochloreaemia due to persistent vomiting. They considered that the latter caused the renal insufficiency. A tubular nephritis, interstitial oedema with moderate infiltration of inflammatory cells and very few glomerular lesions were found. Normal blood-chlorides were established by hypertonic saline infusions and the patient recovered quickly.

Renal insufficiency may be one of the outstanding complications of haemolytic reactions, after transfusion of incompatible blood in pregnancy. De Gowin and Harden⁴³ reported in a study of 2,128 transfusions of stored blood that haemoglobinuria occurred in 5 (0.23 per cent), and death in 2 (0.09 per cent) cases. Berstein⁴⁴ and Brainard⁴⁵ reported anuria in pregnancy following transfusion of compatible blood as determined by our present agglutination tests. Wiener and Peters⁴⁶ reviewing intragroup haemolytic reactions after Landsteiner and Wiener's⁴⁷ discovery of the presence of an iso-glutinin, anti-Rh, classify them into (1) those occurring in patients receiving repeated transfusions of Rh positive blood and (2) those occurring in patients in or after labour who have not received previous transfusions. Our case 4 is a classical example of the mechanism responsible for the renal failure, an "immunisation of the Rh negative patient to the repeated transfusion of the Rh positive agglutino-gen". That such intragroup haemolytic transfusion reactions may occur especially in Rh negative mothers whose Rh positive foetuses were affected with erythroblastosis or haemolytic anaemia of the new-born was supported by Levine,⁴⁸ Levine, Burnham, Katzin and Vogel,⁴⁹ Wiener,⁴⁹ Boorman, Dodd and Mollison,⁵⁰ Loutit,⁵¹ Harrison and Meacock,⁵² and others.

The occurrence of isohaemolysins, alpha and beta, in higher titres in postpartum women may provide an explanation for the specific stimulation in hetero-specific pregnancy: Group A or Group B foetus in a Group O mother. (Wiener and Peters,⁵⁴ Jonsson.⁵³)

The subject of renal failure after incompatible blood transfusions was further reviewed by Jewesbury,⁵⁴ Wiener and his co-workers, De Gowin,⁵⁵ Kilduffe and De Bakey,⁵⁶ so that we indicated in our paper only the features of particular interest to the obstetrician.

Butler, Danforth and Scudder⁵⁷ recently presented a case and a review of the Rh factor in intragroup blood transfusion reactions in obstetrical patients. The treatment was directed towards correcting the acidosis, maintaining fluid and electrolyte balance, and restoring blood volume and plasma proteins. Adrenal cortical extract and hypertonic saline were administered to cause sodium retention and potassium diuresis, to protect the patients from the convulsive action of the increase of potassium salts in the blood, a method worth remembering. Among 25 similar cases selected from the literature, haemoglobinuria was noticed in 12, convulsions in 10, hypertension and oedema in 6. Rapid progression to suppression of urine was present in 3 fatal cases. There were 5 deaths in these 25 cases.

Reference seems necessary to the present conflicting views on the mechanism of production of the renal lesion and the suppression of urine by an incompatible transfusion in pregnancy.

Two explanations are given:

(1) Mechanical blockage of the tubules by acid haemoglobin. (Ponfik,⁵⁸ Baker and Dodds,⁵⁹ De Gowin and co-workers, de Navasquez.⁶⁰)

(2) Irritating or toxic products released by the haemolytic reaction have a direct

effect on the kidneys (Bordley,⁶¹ De Gowin and co-workers, Hesse and Filatow⁶²).

The renal lesion is characterized by oedema and cellular infiltration of the interstitial tissues, degeneration and necrotic changes in the collecting tubules, deposition of pigmented casts, dilatation of the convoluted tubules. The glomeruli are normal. The pathology of the kidneys resembles strikingly the pathological findings in "crush injury".

Godwin and McCall⁶³ have described cortical necrosis following perforated gastric ulcer with peritonitis and made bacterial toxins responsible for the glomerular capillary dilatation. They stressed that shock with the resulting capillary stasis and haemoconcentration may have been a contributory cause of renal ischaemia.

Bratton⁶⁴ described anuria with casts not associated with blood transfusion in 9 fatal cases of antepartum bleeding. The case records showed that 4 patients had "septic abortion" with suppression of urine and one had raised blood-urea. Postmortem findings were tubular degeneration, necrosis of occasional cells, formation of cellular and haematogenous casts, especially in the collecting and discharging tubules, unaffected glomeruli, interstitial oedema with small foci of subacute inflammatory infiltration in relation to the blocked tubules. Apart from engorgement the vessels showed no other abnormality. Bratton's microscopical description differs from the previous pathological findings of Jeddeloh.¹⁵ Bratton pointed out that the histology of the kidneys suggests a toxic lesion, but as the onset of anuria may precede abortion the toxic process is not necessarily puerperal in origin but may be initiated previously.

We think that one cannot rule out the question of drug-ingestion in some of Bratton's cases of septic abortion, and this

factor, therefore, may be responsible, too, for the postmortem picture.

The third type of suppression of urine in early pregnancy, obstruction to the outflow of secreted urine, is a subject that has given rise to much discussion and stimulated many investigations since 1939.

In 1941 Bywaters and Beall,^{65, 65a} and their associates at the British Postgraduate Medical School, published a paper showing the close association of crush injuries with renal failure. After the heavy air-raids on London the attention of the medical world was focused on that problem.

Bywaters *et al.*,⁶⁶ Dunn *et al.*,⁶⁷ Bywaters and Dible,⁶⁸ Darmaddy *et al.*,⁶⁹ and several others gave a comprehensive description of the pathology of the kidney damage, consisting of degenerative and necrotic tubular lesions localized most frequently in the ascending limbs of Henle and the second convoluted tubule, with brown casts (myohaemoglobin) in some tubules.

Young and McMichael⁷⁰ stressed the analogy of the shock-azotaemic state following the trauma of difficult labour with the crush syndrome.

Young⁷¹ referred to the similarity of biochemical and renal changes in the "crush syndrome" and the syndrome in concealed accidental haemorrhage. In his papers Young⁷² has given us much enlightenment on the causes of renal failure after utero-placental damage. He drew the following conclusions:

Concealed accidental retroplacental haemorrhage is a massive utero-placental lesion of ischaemic origin in which the acute renal lesion with haematuria, oliguria, suppression and uraemia may ultimately develop. The toxic substance giving rise to tubular degeneration is derived from tissue autolysis. Shock and haemolysis, so often present, may have a similar origin.

In an analysis of the aetiology of renal failure in 79 cases of accidental haemor-

rhage in late pregnancy, 5 cases (6.5 per cent) showed renal impairment. Among 59 consecutive cases of obstetrical haemorrhage (postpartum, placenta praevia, accidental) in only 5 of the 10 accidental was renal impairment demonstrable. Young concluded, therefore, that shock from haemorrhage has no essential part in the initiation of the renal lesion. The second factor, haemolysis with tubular blockage, is also not solely responsible for the renal failure following accidental haemorrhage. Young postulated a third factor: a toxic material is generated in the dying retroplacental concealed haemorrhagic utero-placental lesion which is responsible for the renal syndrome in accidental haemorrhage. The analogy is drawn from the "nephrotoxic theory" in crush syndrome where the source of the toxin has been regarded as ischaemic muscle.

The latest description of 2 cases of renal failure following abortion comes from Dingle.³¹ One case, a 6 months pregnancy, had a severe pre-eclamptic toxæmia, in which the added trauma of induction produced shock and kidney failure. The post-mortem examination disclosed complete bilateral cortical necrosis. The second case was that of a patient who fell, and probably had a traumatic accidental haemorrhage, which produced haematuria, shock and oliguria with uraemia. The patient made a complete recovery after 10 days oliguria and uraemia (blood-urea up to 356 mg. per cent). In both cases there was haematuria, followed by oliguria and a marked rise in blood-urea following delivery, which was accompanied by a sudden alarming drop in blood-pressure due to shock.

In the second case there was a marked tendency to thrombosis with lowering of the blood coagulation time, a complication noted also by Davidson and Turner⁷³ and Gibberd.³⁰

Dingle indicates, from a study of the

recent literature, that the aetiology of the condition may lie in a damaged placenta. Her cases seem to offer convincing evidence for those who regard renal anoxia secondary to hypotension (shock) as the mechanism of renal failure.

Although cortical necrosis of the kidneys could be produced experimentally by *Staphylococcus aureus* toxins (Von Glahn and Weld,⁷⁴ De Navasquez^{60a}), surprisingly none of the cases described in the last 10 years were associated with septic abortion, a fact that seems worth mentioning, especially since Dunn and Montgomery⁷⁵ reviewed in their 8 cases of renal cortical necrosis a variety of infections, such as sore throat, scarlatina, post-operative streptococcal infection, pneumonia, diphtheria, "grippe" and dysentery.

It is interesting to note here that sulphapyridine anuria has a similar mechanism and clinic-pathological picture (Ravid and Chesner⁶⁶), and in cases of septic abortion under treatment with sulphonamides it is essential to exclude the sulphonamides as a possible factor in the urinary upset.

Darmaddy, *et al.*,⁶⁹ have recently (1944) reported that they have seen many cases with extensive muscle ischaemia and necrosis without traumatic uraemia.

The "toxic substance" has not yet been identified, so the theory is still *sub judice*.

In the last 2 years we have failed to find signs of renal failure in many cases of difficult labour with severe trauma (failed forceps, severe lacerations, etc.).

Reference is made to a rare cause of oliguria in early and late pregnancy—*allergic or angio-neurotic oedema*—by Seley.⁷⁷ The existence of oliguria and anuria due to toxæmia in early pregnancy is rare. Acute glomerulo-nephritis, pyelonephritis, dehydration, hyperemesis gravidarum, etc., are conditions which it is not our intention to discuss in this paper.

TREATMENT.

The salient features of the conservative treatment of oliguria and anuria following abortion consist in:

(1) Ample fluid intake to overcome the negative fluid balance. Dieckmann and Kramer⁷⁸ defined oliguria as the excretion of less than 600 c.cm. of urine within 24 hours, and anuria as the absence of urine for 12 or more hours. We have found that 5 per cent hypertonic dextrose in physiological saline in amounts of 3 to 4 pints daily by slow intravenous drip has been the most efficient means of increasing diuresis and replenishing the mineral content of the plasma.

(2) Alkaline fluids by mouth, prophylactically, for recipients of blood-transfusion, in the form of sodium citrate 90 to 180 gr. daily. Two per cent sodium sulphate intravenously can be given as a stimulating diuretic. We have had no experience with lactate solutions which were strongly recommended by Dieckmann and Kramer.

(3) High doses of ascorbic acid as a diuretic, and vitamin B₁ to prevent or improve severe vomiting. Both proved useful in the reported cases.

From the operative measures which have been advocated and reported as successful in the treatment of anuria, decapsulation, splanchnic block and cystoscopy with ureteral catheterization were employed in our cases.

(4) All cases of septic abortion or of shock were put on intake and output charts and had the blood-urea and catheter specimens of urine examined as a routine.

Decapsulation was attempted in Cases 1 and 4 of our series. We could not convince ourselves that the kidneys in these cases were under tension at operation and we considered the operation tilted the scale rapidly against the patients. Gibberd⁸⁰ has already given very strong evidence from the

pathology of the fallacy of employing decapsulation in cortical necrosis. There is nowhere in the literature the slightest proof that mechanical compression from without cuts off the blood-supply to the glomeruli. The vessels were the very opposite of compressed; they were engorged. The clinical course, biochemistry and histology of cortical necrosis, points to glomerular failure as the cause of progressive renal insufficiency, so that mechanical pressure on the tubules by the acute swelling of the confined kidneys is quite unconvincing as a cause of anuria.

Cabot and Iber,⁷⁹ who presented the largest single collection of cases of total anuria from different causes at the Mayo Clinic, do not believe that decapsulation has any place in the modern treatment of this condition.

Madding and his associates³⁹ advise conduct of the treatment of anuria in pregnancy on modern conservative lines, as in their own successful cases.

Kellar and Arnott¹³ had discouraging results with decapsulation in cortical necrosis and advised staving off anuria by other means.

Johnstone²¹ was impressed with isotonic sulphate solution as a means of stimulating diuresis in a probable case of postpartum cortical necrosis.

Among the 48 cases of symmetrical cortical necrosis in the pregnancy of Duff and Moore's series, Crook's case is the only one which recovered after decapsulation. Of their 15 fatal cases of renal cortical necrosis following abortion, there was not a single one in which decapsulation was of avail.

A further analysis of the reported 8 recoveries of clinically diagnosed cases of cortical necrosis in pregnancy showed that only Crook's patient had a decapsulation—another argument against a surgical procedure which should have no place in the treatment of renal failure in pregnancy.

Splanchnic Block. The limitations of existing methods of treatment of oliguria and anuria in pregnancy encouraged us to attempt, in two of our most serious cases, a bilateral posterior splanchnic block, according to the method of Kappis. James⁸⁰ had recently described excellently the technique of this type of regional analgesia.

Our case 4 was a septic incomplete abortion with severe haemolytic transfusion reaction, due to Rh incompatibility, in which bilateral splanchnic block with 1:2000 Anethaine Glaxo (an analgesic solution of amethocaine hydrochloride, with the addition of adrenaline in 1:200,000 concentration), was performed to stave off renal failure. The response was rapid and the patient recovered. Case 5 was a patient with septic inevitable abortion and symmetrical cortical necrosis, who responded dramatically to a second bilateral splanchnic block with 1:2000 Anethaine Glaxo, after all conservative measures and a first splanchnic block with $\frac{1}{2}$ per cent procaine had failed to promote diuresis. The literature contains only a few reports of splanchnic nerve block as a method of treatment of suppression of urine.

Neuwirth⁸¹ published the first conclusive evidence of the relief of reflex-anuria by means of splanchnic block in anuria. Havlicek,⁸² Rubritius,⁸³ and Haslinger⁸⁴ were other continental writers who confirmed the usefulness of splanchnic block in anuria.

Peters⁸⁵ presented a case of prolonged anuria after blood transfusion, in which a single splanchnic block, after failure of other measures, produced diuresis within a few hours. He explained the mechanism of splanchnic block as the breaking of the reflex arc through which sympathetic reflexes pass. Experiments show that irritation of the splanchnic nerve causes oliguria, and section of the nerves conversely, polyuria. (See Bernard,⁸⁶ Milliker and Karr,⁸⁷ and Caldwell, Marx and Rown-

tree.⁸⁶) Peters also discussed the advantages of splanchnic nerve block over spinal anaesthesia, which was recommended by Hayes and Paramore,⁸⁹ and Cubitt.⁹⁰

Russian authors (Hesse and Filatow⁹²), made experimental observations that renal vasospasm occurs in haemolytic reactions as a result of the liberation of depressor substances acting directly on the vessel walls, with consequent impairment of kidney function. They were impressed with the results of immediate transfusion of compatible blood in small quantities experimentally and clinically. Among 16 cases of severe renal failure following blood transfusion, they had only 2 deaths. Visnoscski⁹¹ treated cases by splanchnic block successfully.

To be efficient, spinal block must be at a high level because some fibres making up the splanchnic nerve arise from as high as the 4th dorsal segment. Splanchnic block gives a more complete interruption than spinal anaesthesia which works as high as the 6th dorsal segment only.

In our experience splanchnic block does not produce motor weakness or paraesthesias. Both our patients were able to move about in bed and there was no appreciable fall in the blood-pressure.

Definite conclusions cannot be drawn as to the exact mechanism of splanchnic nerve block in the relief of suppression of urine in pregnancy, due to cortical necrosis. The predominant vascular element—*ischaemia*—is striking and arteriolar and arterial spasm may be the first events to determine all the later cortical lesions. The block, should, therefore, be used early.

The renal picture in dogs and rats in the classical Goldblatt⁹³ experiments, after clamping the renal arteries, is not unlike that in our described cases of cortical necrosis. Splanchnic block may be "releasing the clamp" which produces renal anaemia.

We know Goldblatt's experiments are stated not to be due to nervous phenomena. Splanchnic block is not a panacea for all cases of oliguria or anuria, but, to our knowledge, these are the first 2 cases of suppression of urine in early pregnancy in which conservative methods and splanchnic nerve block have given good results and probably prevented a fatal result.

Catheterization of the ureters was employed in 4 of our cases, prior to any other surgical procedure, first to assist in the diagnosis of the renal pathology, secondly to exclude blockage of the ureters. In both cases of cortical necrosis the operation appeared to fail. In the first case of "septic abortion kidney" with blockage in the convoluted tubules by masses of pigment, it was also impossible to promote diuresis by catheterization of both ureters.

DISCUSSION AND SUMMARY.

A clinical, and in part, pathological study of the 7 cases we have collected shows that renal failure is one of the most serious of the complications of pregnancy. Although the condition has been well known for many years, the clinical picture has gained more interest since the publication of papers dealing with traumatic uraemia ("crush syndrome") in this war.

Age. The ages of the patients ranged from 19 to 45 years. The majority of the patients fall in the higher age-groups.

Gravida. There were 2 primiparae in the group. All the other patients were multiparae. Thus it would appear that multiparity predisposes to these renal complications.

Stage of Pregnancy. We have found our abortion cases distributed from 12 weeks to 24 weeks. It is interesting that all cases of renal cortical necrosis occurred at a time when the placenta had already developed.

Aetiology. The cases discussed allow us to group the renal complications into those which occur in :

- (1) non-septic abortions;
- (2) septic abortions.

It should be emphasized that 5 out of our 6 cases of abortion were septic, a figure that indicates the importance of the infection factor in the causation of the acute renal insufficiency in this series. We cannot of course, completely exclude the possibility of the sulphonamides having some part in the aetiology.

CONCLUSION.

An extensive summary and analysis of the world's literature on renal failure complicating abortion has not been reported previously. Up to 1941 only 15 cases of abortion with renal failure among 48 cases occurring in pregnancy could be discovered. Since then only 2 cases (Dingle's) and our 2 have been reported. The poor prognosis is evident from the fact that up to the present time only 9 cases of cortical necrosis in pregnancy with recovery can be traced in the available publications.

An outline of the treatment of oliguria and anuria following abortion is given. Decapsulation should have no place in the treatment of renal failure in these cases. Among the 9 recovered cases of renal cortical necrosis in pregnancy in the literature, 8 recovered without this surgical procedure. Both our patients upon whom decapsulation was performed died. Two of our cases with suppression of urine and azotaemia responded excellently to bilateral splanchnic block with 1:2000 anethaine.

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The Mother in Industry *

BY

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In the short time at our disposal I shall try to suggest subjects for discussion rather than give a detailed account of my experience as a Medical Inspector of Factories, of the mother in industry. I propose to do surface anatomy on this mother and to divide her into (a) the expectant mother, (b) the nursing mother, and (c) the mother with young children, with a foreword on the prospective mother for this is the keynote to protective factory legislation for women.

The Factories Act of 1937, the previous Factories Acts and the Orders and Regulations made thereunder had in mind the fundamental physiological function of women, that of childbearing, and to prevent any detriment to the function has determined the law with regard to women's employment generally, and specifically in those "dangerous trades" where women are allowed. Some restriction on women's employment in industry is founded on tradition, and on the supposed greater susceptibility of women to certain toxic substances, i.e. lead compounds and benzene, but in my view this is a complicated issue.

It would be difficult to prove on physiological grounds that women (apart from pregnancy) are more susceptible than men to injury where there is a health risk common to both. There are, however, in addition to general statutory restrictions on

the employment of women in industry, certain special restrictions relating to particular processes to which reference must be made. These are, with one exception, lead processes, and these restrictions on employment of women have been "imposed on the ground that the use of lead involves special dangers to women."¹ If I may express my view of this official statement it would be to the effect that since lead has been used as an abortifacient, the prohibition from employment in lead processes, involving special risk, of women of child bearing age could be supported on medical grounds.

Both women and young persons (i.e. those under 18), may, however, be employed legally on work involving the use of lead compounds (approximately, material containing less than 5 per cent of soluble lead compound). Where such work is undertaken certain precautions have to be taken to control the risks from lead dust or fumes and periodic medical examination is required. Cases of lead poisoning or lead absorption among women and young persons so employed are in fact practically unknown.

Other health risks in industry are on the whole common to men and women, the factor determining ill effects being the intensity and duration of exposure to the hazard. The element of susceptibility can rarely be predetermined and is probably not influenced by sex, although it may be by habits of individuals. It has been suggested that women are more susceptible

* A paper read at a Course for Assistant Medical Officers of Health at the British Postgraduate Medical School, November 20th, 1945.

than men to benzene poisoning but this is not supported by a study of groups of workers of both sexes exposed to similar concentrations.²

It is possible, however, that women exposed to benzene may show the harmful effects in an obvious way peculiar to women—by menstrual changes. The alleged susceptibility of women to lead poisoning, as shown by abortion, may be capable of a similar explanation.

(a) *The Expectant Mother.*

There is not, contrary to the popular view, legislation forbidding the employment in industry of women during any stage of pregnancy and women, in larger numbers in wartime than in peace, have in fact been so employed. This employment is terminated either on the instigation of the worker or the employer and fortunately there is practically no disagreement between these two as to when during pregnancy industrial occupation should cease. In wartime there has been the Essential Works Order, controlling release from work, but permission to leave employment on account of pregnancy would not be withheld if desired by the woman. If she elects to remain at work against the wishes of the employer the question falls to be decided by the National Service Officer, but I think such cases are rare.

We very rarely, too, hear of accidents in industry to women who are pregnant. You might think this is odd as women are every year involved in quite a large number of industrial accidents and it might so happen that some of these women were pregnant. I think the explanation lies in the care—without the spur of legislation—that is given to women in industry in this condition, and perhaps to the fact that there is no hard and fast rule as to how long such employment may continue—each case being considered

on its merits in relation to the individual's state of health, her home circumstances and the nature and conditions of her employment. These desiderata are most conveniently and efficiently satisfied when there is medical (including nursing) supervision in the factory, but such is the public conscience in this country towards the expectant mother that the consideration accorded her by the industrial laity does much to prevent injury to her, although this consideration (prompted by principles which can be well understood) may sometimes have the effect of terminating prematurely her period of useful employment.

The usual procedure where there is a medical service in the factory—including a whole- or part-time doctor and one or more nurses—is for the woman to seek advice from this department as soon as the fact of pregnancy is established. Then she is advised in general terms and as to attendance at the local authority antenatal clinic, while her work in the factory is reviewed in the light of the new circumstances. She is, or should be, removed from contact with toxic substances such as trinitrotoluene, benzene or lead compounds, and from cold, wet work, and from heavy work, particularly where this involves muscular strain of an intermittent or jerky nature, and from work which—and this is very rare in my experience if thought is given to the remedy—requires continual standing. The ideal is, of course, in a "sedentary" job to alternate sitting with standing, and we all know that exercise in moderation is good for the pregnant woman. The hours of work would, in the ideal case I am considering, be modified if necessary to the particular needs of the individual and as a rule night-employment (permitted to women during the war) would be generally avoided. You may say, and cogently, that such changes, perhaps carrying with them anything from a

diminished wage-pocket to termination of employment will tend to postpone the revelation of pregnancy until it becomes apparent. This is the very thing that is to be avoided, if only on account of the relative frequency of miscarriage during the first 3 months of pregnancy. Some firms have therefore declared in advance their policy of non-dismissal (where dismissal is legal) on the ground of pregnancy, and sometimes monetary benefits are given to make up for shortened hours and change of employment. One firm, with the object of getting the women to return after childbirth, introduced a scheme by which each woman on reporting her pregnancy became entitled to £1 a week for 3 months. Most women were advised to leave this firm's employment at about the 6th month.

In general, it is the economic urge which keeps women at work after the 3rd month of pregnancy, but in this connexion it must be remembered that factory work is not necessarily more exacting than domestic work and where in a factory there is a medical service, the needs of the pregnant woman may receive more constant, expert consideration (in conjunction with the outside health service) than is possible at home.

It is not scientifically sound to determine in general terms the period of healthy employment of women in industry who are pregnant; this must, as I have suggested, be determined to suit the individual needs. We have records of women who have, without untoward incident stayed at work until the 8th month, but this is very unusual. Somewhere about the 20th to 28th week is much more common while, of course, large numbers, including those who are well provided for, leave industry much earlier.

There have been a few instances during wartime of antenatal clinics in factories. These have not set out to compete with Local Authority clinics, but the object has been to keep the workers at work and to

save their time. A firm estimated that 5,244 hours were so saved in 8 months by 115 prospective mothers. The general view, however, is that medical and nursing services in factories will function best if regarded as ancillary to hospital and local authority clinics (and private and panel doctors) and that continuity of ante- and postnatal care can only thus be ensured.

What of the results of this employment? I have no statistics to give you because we are not, of course, officially informed of pregnancy in industry, and it is only by a scrutiny of reported accidents and of notifiable industrial diseases that the complicating fact of pregnancy can be revealed. My recollection over 20 years is of only a handful of such cases. One stands out in my memory—that of a well-built girl in the twenties who had been passed in the pre-war period as medically fit for her job in a sugar refining factory. At the end of the 2nd year of the war, without further medical examination, she had been put on what was described as a "man's job"—filling sugar bags and trucking these (weighing 1 or 2 hundredweights) to a chute. One day after taking a bag on to her truck, she stepped back on to the empty truck of another girl; she fell—but did not report to the ambulance room. The same evening she had a severe haemorrhage followed by a miscarriage. She was 2½ months pregnant and had not reported to the medical department of the factory.

I am telling you of one of the apparent failures of the present system, and that these are generally connected with the early months of pregnancy before the condition has been disclosed to a responsible person in industry will not surprise you. In another case (also wartime) where this also held true, the coroner's verdict was one of accidental death from cerebral oedema following abortion due to being struck at work. In this regrettable case, the woman was aged

40 and a widow—pregnancy had not been disclosed. She was working with 3 other women stacking flour bags, weighing 140 pounds, when the stack collapsed. She and another woman were struck by falling bags, the widow went home and was admitted to hospital 14 days later. Death occurred after 3 days and only at a post-mortem examination, was the fact of pregnancy (4th to 5th month) established. There had evidently been haemorrhage and a miscarriage at home.

To turn from these isolated instances to the record of one factory during wartime, there were in 6 months, among 4,905 female munition workers, 3 cases of abortion treated at the works' surgery and the same number of cases of amenorrhoea. In other words, to be forewarned of pregnancy in a factory is to be forearmed.

(b) *The Nursing Mother.*

In industry the law has stepped in and reads (Public Health Act 1936, S. 205) "if the occupier of a factory or workshop . . . (this was before the Factories Act of 1937, after which the distinction is obsolete) . . . knowingly allows a woman to be employed therein within 4 weeks after she has given birth to a child, he shall be liable . . . etc. In fact it seems almost unknown for a woman to return to work earlier than the law allows and again, it seems that few women return, at any rate to the factory where they were formerly employed, within 6 months to a year of confinement. One factory indeed gave a maternity benefit of £6 to women who returned to work after 8 weeks. It has been estimated among one group of factories that 12 per cent only of married women returned to work after confinement, whereas the percentage of the unmarried was 20 per cent.

A few factories provided facilities in wartime for mothers to nurse their infants, but

I think you will agree that the baby in the first months of life wants more than lacteal attention from the mother, and that it is not really in the best interests of either mother or child for nursing mothers to be employed in factories.

Crèches at or near factories, mostly with a minimal age for admittance of 9 months, are another matter. With individual attention under the supervision of a fully trained nurse the infant is sure of his necessities of life—food, sleep and cleanliness—and he is saved the irregularities which call down his displeasure were he at hand while mother earned the wage packet to supplement, or satisfy, the needs of the weekly budget.

(c) *Mothers With Young Children.*

These can similarly make use of nursery schools until the child is of school age. These are so much more in the province of the local authority that I will conclude by a very brief consideration of the lot of the woman in industry with young children.

Her lot is unenviable, and how she performs the double, or is it triple (with a husband at home), function, I really do not know. What is evident in industry is that the married woman has 65 per cent more absence from sickness than her unmarried sister and this is particularly noticeable in married women under 25 years old. The proportion discharged for reasons of ill health is also much higher among married women.

We shall, I suggest, never change the position with regard to sex differences in absence through sickness (the men's rate is lower than the women's) so long as women have to work away from home and yet continue to fulfil their household obligations. This position creates worse hardships for the women themselves than for the children for whom there is alternative care at home

or in nursery or national schools with the all essential food, rest and recreation.

"The longer you can look back the further you can look forward," said Winston Churchill to an audience of doctors, and it is indeed encouraging after the experiences of 2 great wars to be able to record the useful work, under medical supervision, that the expectant mother has been able to give to industry without detriment to her health.

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A Case of Aplastic Anaemia in Pregnancy

BY

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AND

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It is recognized that all types of anaemia may complicate pregnancy, but aplastic anaemia is a very unusual associated disease. This case history records a temporary acute aplastic anaemia occurring late in pregnancy, with recovery after delivery.

Mrs. W. D., aged 36, 6-para (Case MM. 1814).

Previous obstetric history. Four normal pregnancies and confinements. The 5th (twins) was complicated by hyperemesis gravidarum and anaemia. During the 2nd month the blood count showed the red-blood cells to be 6,160,000 per c.mm. and the haemoglobin to be 83 per cent, but the red-blood cells fell to 3,190,000 per c.mm. and the haemoglobin to 60 per cent at the 5th month, and remained at this level. No further details are available except that she had a severe secondary postpartum haemorrhage.

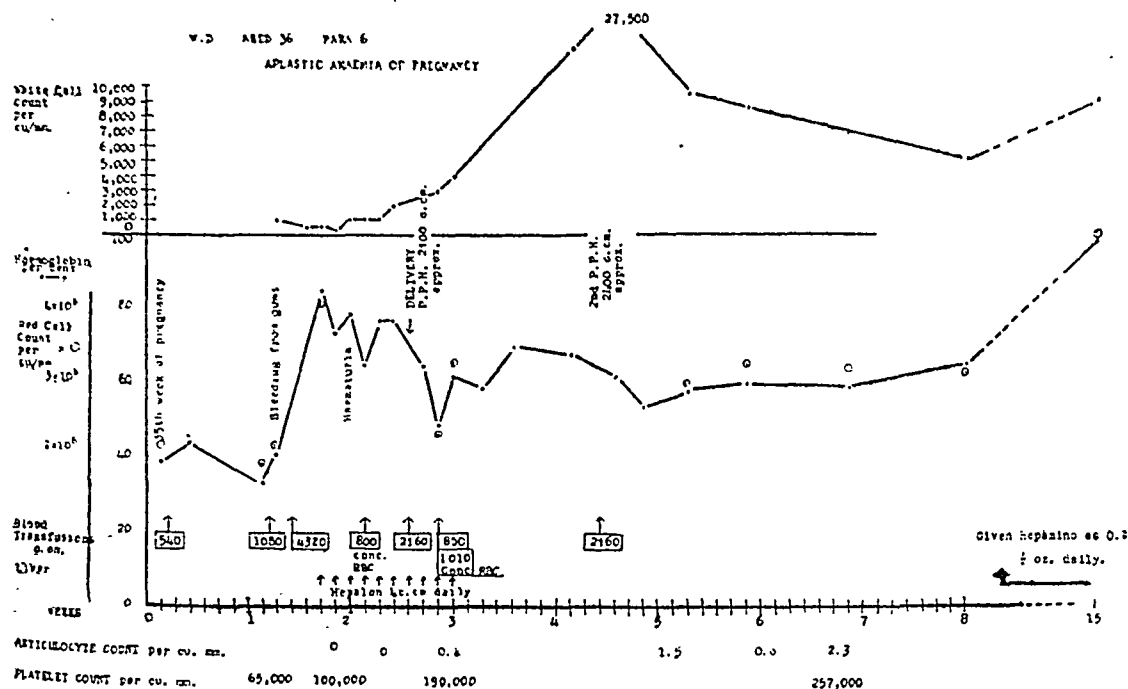
Sixth pregnancy. The woman was first seen at the 14th week, when she seemed rather pale but had no symptoms. Haemoglobin 73 per cent, red cells 4,380,000 per c.mm., and colour index 0.83. She attended the borough clinic and was next seen at this hospital at the 35th week. She had had some swelling of the legs for 4 weeks, and diarrhoea and vomiting for 2 weeks, which had left her with extreme lassitude and breathlessness. She was at once admitted and found to have marked pallor and gross oedema of the feet. The blood-pressure was 120/70. The urine was normal. The uterus corresponded with the expected size, and the liver and spleen were not palpable. The blood-picture was haemoglobin 39 per cent, red cells 2,350,000 per c.mm., and colour index 0.82. Anisocytosis and hypochromic cells present. Rhesus factor positive. Blood group

A. She was transfused with 540 c.cm. blood, which raised the haemoglobin to 44 per cent, but at the end of the first week her blood count had fallen to haemoglobin 33 per cent, red cells 1,840,000 per c.mm., colour index 0.91, white cells 1,000 per c.mm. (polymorphs 40 per cent, lymphocytes 56 per cent, monocytes 4 per cent), platelets 65,000 per c.mm. Sternal puncture showed a great reduction in the number of nucleated cells. The myelocytes were mostly degenerated, but there was an excess of eosinophils. Some giant platelets were seen. The myelogram excluded a megaloblastic anaemia of pregnancy and indicated an aplastic process. She was given 5,400 c.cm. blood within the next four days and her haemoglobin rose to 85 per cent. At this time she began to have bleeding from the gums, purpuric spots appeared on the arms, and within the next 3 days she had epistaxis, melaena and gross haematuria. The white cell count remained very low and fell to 400 per c.mm., but rose again to 2,000 per c.mm. before delivery. During this time she had daily injections of 4 c.cm. Hepalon intramuscularly, but reticulocyte response did not occur. She was also given iron, ascorbic acid and Aluzyme yeast by mouth. She was given 2 further transfusions (see chart), and then labour was induced by high rupture of membranes. She was delivered in 4 hours of a live child, weighing 6 pounds 10 ounces. She had a severe postpartum haemorrhage before and after expulsion of the placenta and was given 2,100 c.cm. blood. Within 3 days her white cell count had risen to 4,000 per c.mm., platelets to 190,000 per c.mm. Haematuria persisted for a few days. The bleeding time was over 15 minutes and the clotting time (Dale & Laidlaw) 1 minute 45 seconds. She had a *Bact. coli* infection of the urine, excessive lochia and pyrexia up to 100.6° F., but her general condition

was greatly improved. Two weeks after delivery she had a sudden secondary postpartum haemorrhage and lost nearly 2½ litres of blood. The uterus was explored under anaesthesia and a placental polyp was removed. Blood transfusions of 2,160

positive. Blood group A. She was not breast fed owing to the mother's poor general condition after delivery.

The patient's husband was also Rhesus positive and blood group A.



c.c.m. were given. After this she made a good recovery. By the 8th week the haemoglobin had risen to 80 per cent and the red-blood cells to 3,650,000 per c.mm., and she was sent home.

From the 7th week onwards she received proteolysed liver (Hepamino, ½ oz. daily) and she continued to take Aluzyne Yeast, ascorbic acid and ferri et ammon. cit., and by the 13th week the haemoglobin was 98 per cent and the red cells 5,000,000 per c.mm. A fractional test meal showed a normal acid curve.

Sterilization was performed 6 months later, and 18 months after delivery she remains well with haemoglobin 80 per cent, red cells 4,800,000 per c.mm., white cells 6,200 per c.mm. (neutrophils 74 per cent, eosinophils 2 per cent, lymphocytes 21 per cent, monocytes 3 per cent, and platelets 484,000 per c.mm.

The baby was healthy. Blood count on the 4th day was haemoglobin 134 per cent, red cells 6,680,000 per c.mm., colour index 1.0. Rhesus

DISCUSSION.

This patient presented the features of an aplastic anaemia complicating pregnancy. The profound normochromic anaemia with reduction in all the cellular elements in the blood and the marked haemorrhagic tendency, together with the bone marrow picture, were consistent with this diagnosis. The absence of megaloblasts excluded the more common megaloblastic anaemia of pregnancy. The subsequent good progress of the patient is much against the possibility of a leucopenic myelosis.

A very careful interrogation was made concerning exposure to known potentially toxic substances such as benzol, arsphenamine, phenacetin, radio-active paint, X-rays, radium and others¹, but none could be

found. It is recognized that an idiopathic aplastic, or severe hypoplastic anaemia may complicate pregnancy^{2,3,4}, but only 14 cases have been reported, and of these the diagnosis is doubtful in 8 from the data available. They have been reviewed by Hurwitt and Field⁵ and their table is

SUMMARY.

A case of acute aplastic anaemia during the latter part of pregnancy is reported in a woman aged 36 years. Recovery occurred after massive blood transfusions and the induction of premature labour.

	Age	Stage of pregnancy	Obstetric management	Outcome	Remarks
1. Ehrlich, 1888	21	First trimester	Abortion	Death	
2. Planchard, 1887	29	At term	Normal delivery	Death	Diagnosis questionable
3. Hanot and Legry, 1889	25	Second trimester	Miscarriage	Death	Diagnosis questionable
4. Ricca-Barbesis, 1908	25	Puerperium	Normal delivery	Death	Sepsis
5. Hirschfeld, 1906	34	First trimester	Abortion	Death	Gangrenous endometritis
6. Hirschfeld, 1906	38	At term	Normal delivery	Death	Died 9 months postpartum
7. Massary and Weil, 1908	21	First trimester	Uninterrupted	Death	Death due to heart failure
8. Jungmann, 1914	29	At term	Normal delivery	Recovery	Diagnosis questionable
9. Larrabec, 1925	30	First trimester	Uninterrupted	Death	No postmortem
10. Muller, 1938	28	Postpartum	Normal delivery	Recovery	Several transfusions
11. Foderl, 1938	23	Third trimester	Normal delivery	Recovery	Several transfusions
12. Nicuwenhuis, 1938	18	Third trimester	Interrupted	Recovery	Severe case
13. Dobriner, Rhoads and Mummel, 1938	30	Three pregnancies	Interrupted	Recovery	Chronic, with exacerbation
Hurwitt and Field, 1939	27	First trimester	Uninterrupted	Death	Severe case
Bigby and Jones, 1946	36	Third trimester	Interrupted	Recovery	Several transfusions

appended with our case added. Only 1 was a true chronic aplastic anaemia; she had exacerbations during 3 pregnancies and improvement following termination on each occasion. The others were acute anaemias discovered during pregnancy or the puerperium. Of the 14 cases, only 5 recovered, and it is significant that in all these cases pregnancy was terminated before recovery took place. Our case confirms the beneficial effects of termination of the pregnancy.

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A Home-made Repositor for Chronic Inversion of the Uterus

BY

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On August 24th, 1944, a Bhil woman, aged 25, was brought to the Mission Hospital at Dohad. She gave a history of having been delivered of her first baby 5 days previously. The bowels had not been moved for 5 days, urine had not been passed for 4. She also described high fever with rigors on each of the previous 5 mornings. There had been slight abdominal pain for 4 days, no vomiting, and the lochia was scanty. The baby was alive and well.

On examination she looked very ill and was very anaemic. There was not any tenderness or rigidity in the abdomen but a midline mass, simulating the uterus, extended from the symphysis pubis to 2 finger-breadths above the umbilicus. The edge of the spleen was palpable on inspiration.

On admission to the ward the temperature was 101°F., pulse 120 and respiration 26. She was catheterized and relieved of 26 ounces of urine (acid; trace of albumen; no sugar) and put on a mixture containing quinine sulphate, gr. 5, t.i.d.

The next day the nurse drew my attention to a mass at the vulva which she discovered when doing the routine washing. The uterus was not palpable in the hypogastrium, and on vaginal examination I was surprised to find a large mass, which turned out to be the inverted uterus. The lochia was scanty, yellow and very offensive. An attempt to replace the uterus by manual taxis failed.

On further enquiry I learned that the patient had been 3 days in labour and that

the baby had been born only after the midwives of the village had been called in and had exerted much pressure on the abdomen, according to their custom. As the placenta was slow in being born abdominal pressure had again been applied and the placenta was expressed and apparently the uterus with it. Thereupon the patient felt extremely nauseated.

Until August 28th the temperature varied between 100 and 102°F. but after this date it did not rise over 101° and swung as low as 99°. The pulse varied between 120 and 140.

On August 31st the quinine mixture was discontinued and sulphanilamide, 1 g., t.i.d., commenced.

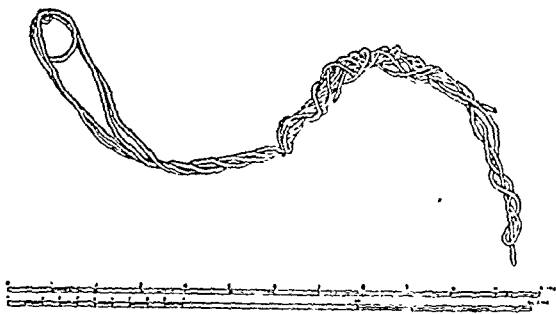
September 2nd. The 12-hourly catheterization was stopped as the amounts of urine which were being withdrawn for the previous 2 days were only 2 to 8 ounces, and the patient was passing urine voluntarily. The bowels were acting normally after a dose of magnesium sulphate on the morning following admission.

September 8th. The sulphanilamide was stopped because the temperature had not been above 99.4°F. since September 3rd, the pulse had steadied at 120 and the lochia had practically ceased. Blaud's pills, gr. 10, t.i.d., and liver injection, 2 c.cm. intramuscularly on alternate days, were commenced.

September 15th. I had written to Bombay, to a firm of surgical instrument makers, for an Aveling's repositor. But after 10 days I got a reply saying they had

none in stock so I decided to attempt to make something myself which, if possible, would avoid an alleged disadvantage of the Aveling model of which a textbook gave warning, viz., after replacement of the uterus has been accomplished there is said to be difficulty sometimes in getting the head of the Aveling repositor out of the uterus if the cervix contracts in behind it.

The model I evolved was simply an S-shaped contrivance made of galvanized iron wire, of 11 and 14 gauge, with a torpedo-shaped end to be applied to the uterus thus keeping the cervix sufficiently dilated to allow of the withdrawal of the repositor (see illustration).



After sterilizing this home-made repositor and after giving the patient a Dettol douche, I placed it in position against the inverted fundus and packed the vagina with a sterile gauze roll to keep it from slipping. Four bandages from the free end of the S tied to a bandage round the waist, which was steadied by another bandage brace-like over the shoulders, held it in position. With the bandages taut the springiness in the wire S exerted a steady pressure on the uterus. Elastic was not available.

September 16th. After 24 hours I removed the apparatus. The uterus was certainly being replaced but I was disturbed by the way the end of the torpedo, blunt

though it was, had cut into the muscle of the uterine wall. Perhaps it was only to have been expected. As an improvement the torpedo frame was padded with sterile lint and cotton wool bound on with a sterile bandage, taking special care to put an extra amount of padding on the 'point.' Over this a rubber condom was drawn to keep the padding from becoming soiled and septic. This was tied at the bottom to prevent discharge seeping inside. Again over this a second condom was pulled and tied for additional security. Now it could not possibly cut into the uterine wall as the frame could not be detected through the padding. After a douche the repositor was reinserted and packed into position.

September 17th. On vaginal examination to-day the fundus was found to be level with the external os.

September 18th. For the past 4 days the temperature has been elevated but not exceeding 100°F., pulse 100. To-day the fundus is well inside the internal os. The repositor was removed and the torpedo end bent a little to lessen the angle it made with the shaft. After a vaginal douche it was replaced.

September 19th. To-day the inversion was found to have been completely replaced as determined by a bimanual examination with a finger inside the uterine cavity. Repositor discarded. To be douched daily.

September 20th. Temperature 98.4°F.; pulse 100 yesterday and to-day.

September 26th. On bimanual examination the uterus was found to be well involutioned. Cervix closed.

September 28th. Discharged. Temperature and pulse normal for the past 7 days.

I am indebted to Mr. Leslie Baxter for the drawing of the repositor, made after it had achieved its purpose.

INDEX TO CURRENT LITERATURE

In this Index an endeavour will be made, so far as conditions permit, to maintain an up-to-date record of all titles bearing on obstetrics and gynaecology and the infant. The classification aims at making immediately available for the reader the titles under the various subject headings. In the majority of instances the title is obtained from the original publication. Where this has been impossible, the title has been obtained from the abstracting journal shown in brackets. Reprints will be welcomed and should be sent to the Editor.

Any inquiries should be addressed to Miss D. F. Atkins, British Post-graduate Medical School, Ducane Road, London, W.12.

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pensatory pause." They concluded as follows: "the confusion that has existed regarding the response of the human uterus to ephinephrine resolves itself into an interpretation of what constitutes inhibition. The apparent inhibition claimed by one group, we believe, is the refractory state of muscular activity rather than a drug effect. From our own observations and a more critical interpretation of the curves published in the literature we believe that epinephrine stimulates the labouring and puerperal uterus to contraction." Woodbury and Abrew⁷ attempted to reconcile these different results by showing that the effect of adrenaline depended upon the dosage and rapidity of absorption. Thus they found that rapid intravenous injection of 0.1 mg. caused immediate uterine contractions which followed each other so closely that the uterine pressure remained elevated between contractions. The amplitude of the contractions was, however, decreased when doses of 0.01 to 0.02 mg. were administered over a period of 6-10 minutes. They concluded: "These inhibitory effects are in entire agreement with the previously published observations of Rucker, who usually administered the drug by the hypodermic avenue. Divergent results from different laboratories may sometimes be explained by the fact that the drug was administered by different routes."

When the experiments suggesting an inhibitor effect of adrenaline on the pregnant uterus *in situ* were published, it occurred to one of us (J.A.G.) that the difference in the observed effect of adrenaline on the human uterus outside and inside the body might be due to differences in the concentration of adrenaline. In early experiments on the excised uterus much higher concentrations of adrenaline were customarily used than was later found to be necessary. To decide this point tests were made by Gunn and

McLachlin in this laboratory to determine the effect on the excised pregnant human uterus of minimal effective concentrations of adrenaline. Though this effect varied with different uteri it was usually from 1 in 10^6 to 1 in 10^7 and the response was uniformly motor. In these experiments, the strips of muscle were obtained during classical Caesarean section and came therefore from the upper part of the uterus. In the course of more recent experiments, similar, except that the low operation was used so that the strips came from the lower uterine segment, the muscle seemed to react to much lower concentrations of adrenaline. It appeared that there was a difference in sensitivity to adrenaline of the upper and lower segments of the uterus at term. Further observations were made, therefore, not only to explore this possibility but also to determine the effect of minimal concentrations of adrenaline on uterine muscle at times other than term.

METHODS.

The technique employed was essentially that described by Gunn⁸

The apparatus used for recording the movements of the muscle was of the familiar type used for excised mammalian tissues. Locke's solution was used as the immersion-fluid. In some experiments, by a modification previously used by one of us (C.S.R.), the glass rod used to fix the one end of the uterine muscle strip was provided with 2 hooks opposite to one another whereby 2 strips could be recorded simultaneously in the same container, thus ensuring that both were under identical conditions with regard to temperature, oxygenation, etc.

Usually the uterine muscle was tested within a few hours of its removal, but often further tests were made after the tissue had been stored for a day or so at 4°C. Two points in regard to the behaviour of the

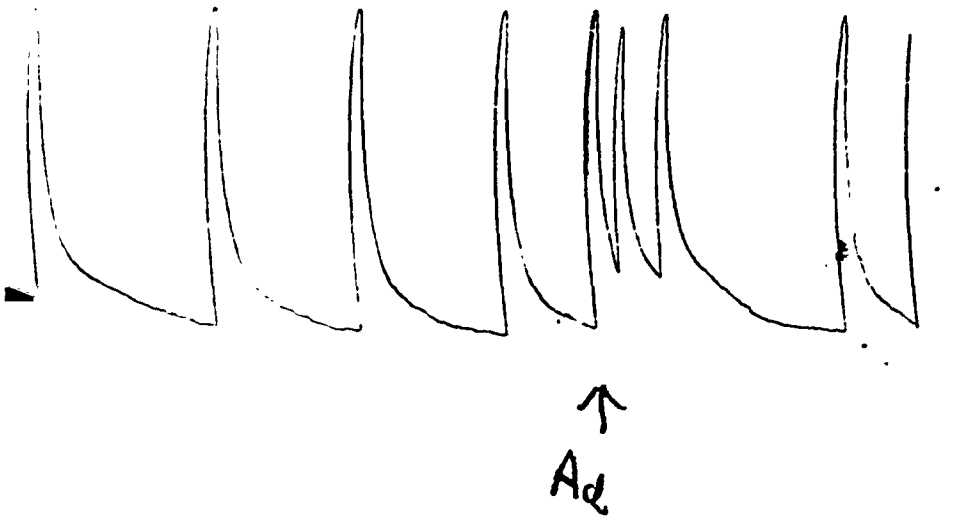


FIG. 1.

Motor effect of adrenaline, 1 in 10 million, on a muscle strip from the non-pregnant human uterus.

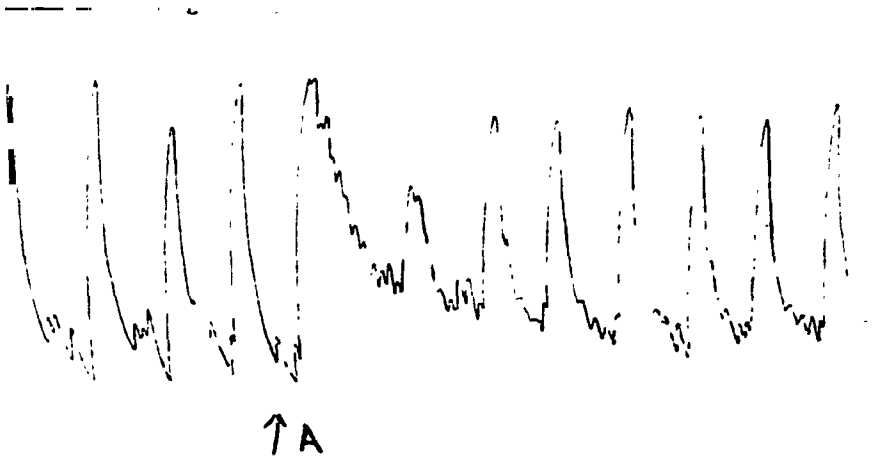


FIG. 2.

Motor effect of adrenaline, 1 in 5 million, on a muscle strip from a uterus in the first 3 months of pregnancy.

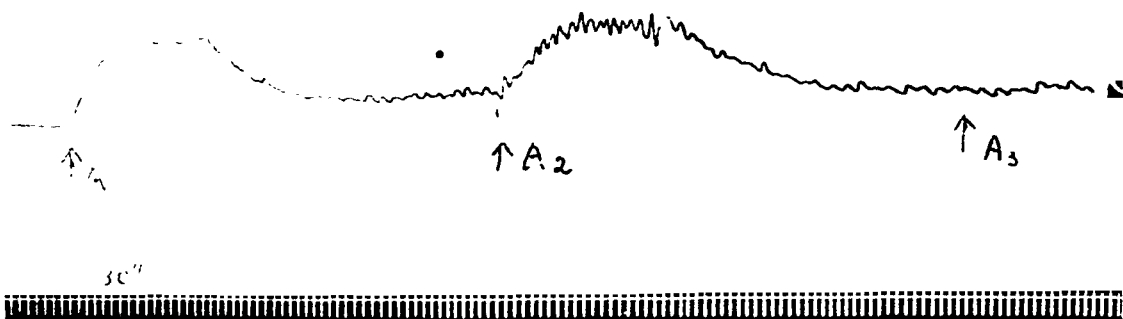


FIG. 4.

Effect of minimal concentrations of adrenaline on a muscle strip from the low.r uterine segment of the full-time pregnant uterus. [A_1 , adrenaline 1 in 500 million; A_2 , 1 in 2,000 million; A_3 , 1 in 4,000 million.]

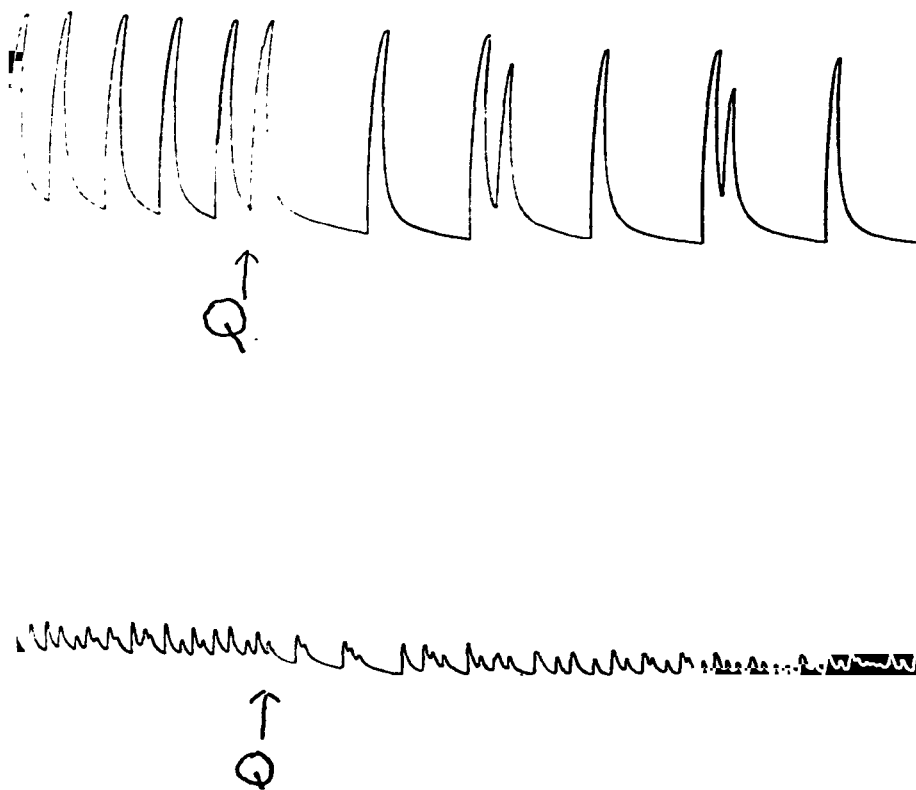


FIG. 7.

Inhibitory effect of 1 mg. quinine hydrochloride on muscle strips from the upper uterine segment (upper tracing) and the lower uterine segment (lower tracing).

J.A.G. & C.S.R.

muscle under these conditions may be mentioned. In the first place, when the muscle was placed in oxygenated Locke's solution at body temperature, a latent period, which might be 2 hours or more if the strip had first been cooled, always elapsed before the strip exhibited spontaneous rhythmic contractions; furthermore, when 2 strips from the same uterus were put up each in a separate apparatus, this preliminary period of inactivity was often almost exactly the same for each. This suggested that under these conditions a particular uterine muscle required a fairly definite time in which to reacquire its excitability. From a considerable experience of this kind of experiment, we have come to the conclusion that it is better to arrange the strip of uterus in the recording apparatus and to leave it alone for some hours, if necessary, rather than to instigate rhythmic movements by any kind of mechanical or chemical stimulus. A second point is that, when the uterine muscle is kept in the refrigerator at 4°C . its sensitiveness to adrenaline is not impaired for at least 48 hours.

RESULTS.

I. NON-PREGNANT UTERUS.

No experiments seem to have been published dealing with the action of adrenaline on the non-pregnant human uterus other than those of Gunn.³ The few experiments we have performed have confirmed his conclusion that the response of the uterus is one of stimulation. This is true also of minimal effective concentrations which are usually of the order of 1 in 10^6 or 10^7 . Fig. 1 shows a typical effect of a minimal effective concentration, in this case 1 in 10 million.

2. PREGNANT UTERUS.

A. *First Trimester.*

Such muscle strips that we have been able to obtain in the first 3 months of preg-

nancy have shown a motor response to adrenaline in all concentrations above the minimal effective one which is of the order of 1 in 20 million. Fig. 2 shows the effect of 1 in 5 million adrenaline on a uterus 3 months pregnant; the chief effect is a prolongation of the first grouped contraction with a following rise of tone of the muscle.

B. *Second Trimester.*

On 2 occasions muscle strips have been obtained at about the 20th week of pregnancy. The response to adrenaline of one of these strips was weakly motor: that of the other was inconsistent; out of six tests on it over a period of 3 days there was no obvious effect on 3 occasions, a slight motor response once and definite inhibition twice (Fig. 3). In the many experiments

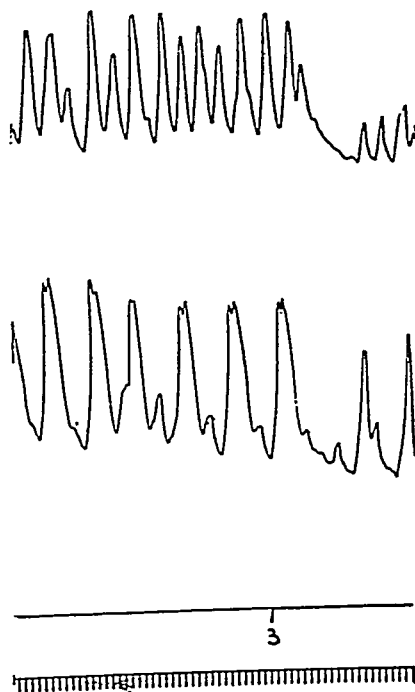


FIG. 3.

Two muscle strips from a uterus 20 weeks pregnant. Tracings showing inhibition to adrenaline, 1 in 500,000. [Pitocin and Pitressin had previously been added without effect.]

we have performed these were the only occasions in which undoubted relaxation of uterine muscle strips occurred following the addition of adrenaline to the bath.

C. Third Trimester.

Many experiments on strips taken from uteri during Caesarean section at or shortly before term have been performed to see whether minimal concentrations of adrenaline ever produced an inhibitory effect, and, as has already been explained, to determine whether there was any quantitative difference in response between the muscle of the upper and of the lower uterine segments.

As to the first point, a scrutiny of the present series of experiments, as well as of previous results obtained by Gunn and McLachlin, has shown that the lowest concentrations of adrenaline ever found effective on strips taken from the upper segment was 1 in 50 million, whereas on strips taken from the lower uterine segment, a concentration of 1 in 2,000 million once, 1 in 1,000 million once, and 1 in 500 million several times, has produced an undoubted motor effect (Fig. 4). In no case did we observe an inhibitory response to adrenaline.

With regard to the second point, a difference in sensitivity of the upper and lower segments might be determined either by comparison of minimal concentrations found to be effective in a series of experiments on the two segments of different uteri, or by a comparison of strips taken from the two segments of the same uterus, especially if these could be kept, as nearly as possible, under identical conditions of experiment.

The experiments already described suggested that for a minimal response the muscle of the upper uterine segment requires a concentration of adrenaline of the order of 40 times greater than that necessary for the muscle of the lower uterine segment.

Though it is, for obvious reasons, difficult to get from the same uterus strips from both upper and lower segments, we have, on several occasions, obtained them from both situations. These were placed in the same bath (as described under 'methods') and were throughout subjected to the same manipulations and to the same environment as regards nutrient solution, temperature, oxygen, time of test, etc.; the leverage used for both was also as nearly as possible the same. Under these conditions it was found that a concentration of adrenaline which produced little or no effect on the muscle of the upper segment might produce a conspicuous motor effect on the muscle of the lower segment. This is illustrated in Fig. 5.

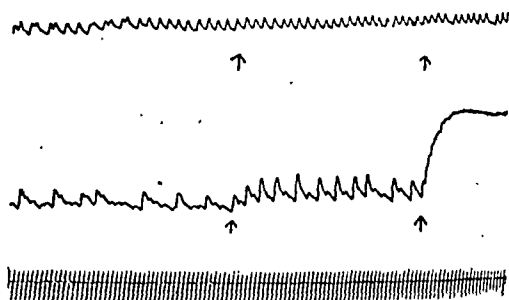


FIG. 5.

Muscle strips from the upper uterine segment (upper tracing) and from the lower uterine segment (lower tracing) of the same uterus before labour. Tracing shows slight motor effect in lower segment strip to 1/10th unit pitressin (first arrow) and a marked motor effect to adrenaline 1 in 10 million (second arrow).

D. In Labour.

We have found that muscle strips from the parturient uterus are less likely to show the rhythmic contractions so easy to demonstrate in strips taken before the onset of labour. This may well be caused by the fact that the uterus of a patient requiring a Caesarean section during labour may be tired and partially damaged as a result of

the condition for which the operation was performed. Nevertheless, on several occasions the response to adrenaline has been tested; in no case was there inhibition, and often the motor effect was clear. Strips from the lower segment seemed more sensitive to adrenaline than those from the upper segment (Fig. 6).

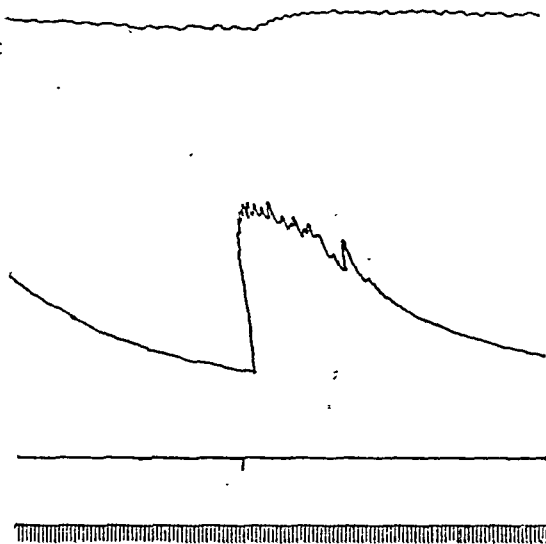


FIG. 6.

Motor effect of adrenaline 1 in 250,000 on muscle strips from the parturient uterus; upper tracing, upper uterine segment; lower tracing, lower uterine segment.

DISCUSSION.

With the confirmation supplied by this paper, there now exists a considerable body of experimentation which is consistently in agreement in finding that adrenaline in any effective concentration stimulates the muscle of the excised human uterus, in the non-pregnant condition, in early and late pregnancy and in labour. The only strips taken during the second trimester of pregnancy gave equivocal results.

When a series of experiments on strips of uterus removed from the upper uterine segment at term has been compared with a

series in which the strips were removed from the lower uterine segment, it was found that higher degrees of sensitivity to adrenaline were found in the latter. When strips from the upper and lower segments of the same uterus were tested the latter again proved more sensitive to adrenaline. These experiments taken together would seem to leave little doubt that the muscle of the lower uterine segment is actually more sensitive to adrenaline than is that of the upper uterine segment. It will be recalled that one of us (C.S.R.⁸) has shown that to posterior lobe pituitary extracts, also, the lower and upper segments show similar quantitative differences in response (Fig. 5).

With the uterus *in situ*, the results found by different observers as to the effect of parental injection of adrenaline have not been constant. The evidence that, in certain cases and administered by certain channels, adrenaline stimulates the intact uterus is convincing. Perhaps the preponderating results so far show that adrenaline either increases the contractions or causes a preliminary increase followed by a diminution in tone. It would be more satisfying if a motor effect were universally found as in the excised uterus. The evidence however, that, especially with small doses, adrenaline may produce a wholly or partly inhibitory effect cannot be overlooked. This may be caused by a genuine and direct effect on the uterine muscle. On the other hand, the recorded inhibition of movements may be caused by some factor other than the direct action on the uterine muscle. Among other factors, for each of which analogies could be found in other organs, the following may be mentioned. (1) The method used (a bag in the uterus connected with a tambour) may not give an uncomplicated record of the contraction of the uterine muscle. The record may be effected for example, by movement of the bag following an increase in uterine tone

or by vascular changes. (2) Adrenaline may act indirectly by liberating another hormone which may alter the response to adrenaline. (3) The uterus may be influenced through the central nervous system. Thus Rucker⁴ records that puncture of the sacral region with a hypodermic needle (without any injection) may cause inhibition of the uterine movements. When the dose of adrenaline is small, it is conceivable that this central inhibitory effect may overcome any direct stimulating action on the uterine muscle.

CONCLUSIONS.

Adrenaline in any effective concentration stimulates the contractions of the excised human uterus in the non-pregnant state, in early and late pregnancy and in labour.

At term, the muscle of the lower uterine segment is more sensitive to adrenaline than is the muscle of the upper uterine segment.

ADDITIONAL NOTE ON THE ACTION OF QUININE (C.S.R.)

Among the many preparations that have been tested on the excised uterus, quinine deserves mention because of its effect on strips from the human uterus at term and in labour.

When amounts of the order of 1 mg. are added to the bath containing 100 c.cm. there is often little or no response; with larger amounts the effect is one of inhibition or paralysis (Fig. 7). When quinine and adrenaline are tested together the one after the other the antagonism between the two substances is very marked (Figs. 8 and 9), an observation which has been made on many occasions by other workers in other spheres.

Whether or not this observation is of any importance in obstetrics is difficult to assess.

Among obstetricians there is a considerable difference of opinion as to the value of quinine in labour. Thus Buddee,⁹ Bourne

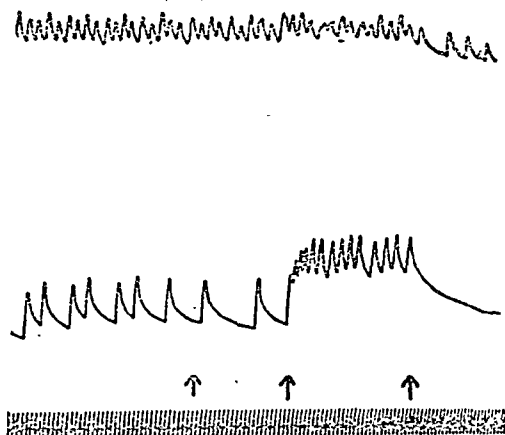


FIG. 8.

Muscle strips from the upper segment and the lower segment of the same uterus taken before the onset of labour. Tracings showing motor effect of adrenaline (second arrow) 1 in 10 million, on the lower uterine segment and the antagonistic effect of 1 mg. quinine hydrochloride (third arrow). At the first arrow a small quantity of pitressin was added without effect.

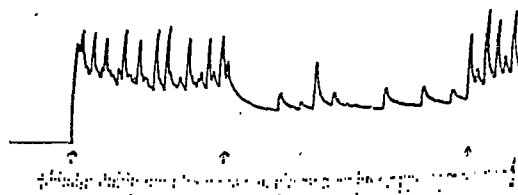


FIG. 9.

Muscle strip from the lower segment of the uterus in labour. Tracing showing antagonism between quinine and adrenaline. First arrow, 1 in 5 million adrenaline. Second arrow, 1 mg. quinine hydrochloride; third arrow, 1 in 5 million adrenaline.

and Burn,¹⁰ and Marshall,²¹ doubt the value of quinine either on the duration of labour, the strength of uterine contractions or in uterine inertia, and there are those who will not use it for fear that the foetus be harmed. At the same time, other clinicians (Garner,¹² Mitchell and Bradbooke,¹³ Luker,¹⁴

Green-Armytage,¹⁵ and many others) maintain that quinine is of real value especially in the first stage of labour. It is in the light of this background of differing opinions that the meaning of the antagonism between quinine and adrenaline should be considered. If it is accepted that adrenaline has a motor effect on the lower uterine segment and that this effect is greater than that on the upper uterine segment, and if quinine really antagonises this effect, one is almost forced to the conclusion that, under conditions of overaction of the sympathetic nervous system, quinine should be of use during labour.

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Moulding of the Foetal Head: A COMPENSATORY MECHANISM.

BY

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It has long been known to obstetricians that compression-force applied in the sub-occipito bregmatic circumference of the foetal head results in some diminution of the related diameters and is accompanied by a compensatory movement of elongation in the mento-vertical diameter. There is very little description of this mechanism in the literature, and this paper attempts to describe how this compensatory movement is brought about, together with its limitations in vertex presentation.

Anatomical factors. The study of the bones and sutures of the vault can best be made by removing the intact vault still attached to a portion of the base. It is clear that the mobility of any two bones along any suture line will depend largely on the breadth of the connecting membrane between their opposing edges. It is also clear that mobility will be something less than this breadth, for in the case of the lambdoidal, coronal and frontal sutures the breadth of the uniting tissue decreases as the base is approached, and where overlapping is actually produced the thickness of the bone edges must be another limiting factor. The maximum amount of movement along these different suture lines can be measured, and is found to take place at that point of any bone which is most remote from its base, and this is, of course, due to the decreasing breadth of the suture from apex to base. The interesting fact about the movements of these bones of the vault lies in the observation that while the upper

portions of the frontal and occipital bones readily respond to forces which tend to depress them, they cannot be made to overlap easily by sliding one bone under the other, and unless very great force is used only slight overlapping is achieved. The impression gained from manipulation of the bones is one of great resistance to any sliding motion. Measurement shows the occipital bone to be capable of an inward movement of $\frac{1}{4}$ inch (6 mm.) at its apex and an inward movement of equal magnitude occurs where each frontal bone reaches the lateral margin of the bregma. From the apex to the base of each bone the depression rapidly decreases. Overlap cannot be accurately measured, but would appear to be no more than $\frac{1}{4}$ inch (3 mm.) at any point where it can be produced. It is sometimes impossible to make the parietal bones overlap along the sagittal suture except by the merest fraction of an inch or with the aid of such force as must rupture the membranous tissue. The reason why the depressing movement should be so much in excess of the sliding movement is possibly due to 3 factors. Firstly, a true sliding motion would be possible only if each bone were entirely mobile instead of being fixed at its base. Secondly, the manner in which the underlying sinuses are attached to the suture tissue tends to limit a sliding movement more readily than the movement of depression. This fact is easily demonstrated by dissecting the dural septum with its enclosed sinus from its attachment along

the floor of the suture. When this has been done the mobility of the bones is greatly increased and they can be made to overlap easily. Thirdly, the decreasing mobility of contiguous bones from apex to base tends to prevent them from sliding one below the other, and where the breadth of the bridging tissue is less than the thickness of the bones, overlap is impossible.

It has been noted that there is some variation from skull to skull of the full time foetus. The sutures are wider in some than in others, and occasionally any one suture may vary irregularly in width from lace to lace. These differences are not necessarily related to weight, but the widest sutures seen were in a foetus weighing 9 pounds 4 ounces. Mobility or plasticity is largely dependent on the width of the sutures, and in some cases overlap can be achieved by manipulation of the bones, but taken over all it rarely amounts to more than $\frac{1}{8}$ inch (3 mm.).

Experimental data. If the scalp be reflected from the skull of a full time normal foetus so that the suture lines are exposed, the immediate effects of compression may be accurately observed. When a force of moderate magnitude is applied in the suboccipitobregmatic circumference there is a movement of the occipital and frontal bones which consists of a bending inwards so that they encroach upon the cranial cavity. This movement is maximal at the apex or highest point of these bones. There is at the same time an upward movement of the vertical portions of the parietal bones and an apparent tendency of the skull to bulge over the area represented chiefly by the posterior ends of the parietals and representing the presenting part in normal labour. As a result of this, the edge of each parietal bone diverges from the other as it passes back from the bregma. The frontal bones tend to come together, and when the force is

considerable very slight overlapping occurs along the frontal suture. Overlapping of the bones along the lambdoidal and coronal sutures is not evident, or very slight. It may appear and feel much more pronounced than it really is if the inward movement of the frontal and occipital bones and the outward movement of the parietal bones are exaggerated. Overlap can be accurately gauged only when the edges of opposing bones are brought as far as possible into the same plane, and when this is done it is sometimes surprising to find divergence where one confidently expected overlap. The biparietal diameter is not significantly reduced by moderate compression-force, but when the force is raised reduction of this diameter brings the parietal bones close together and they may slightly overlap along the sagittal suture. The suboccipitobregmatic diameter may be reduced by as much as $\frac{1}{4}$ inch (6 mm.).

The shape and structure of the parietal bone are such that pressure exerted over the parietal eminence produces a lengthening of the bone when measured with calipers from sagittal edge to base, and this is due to straightening out of that part of the curve which lies between a line passing through the eminence parallel with the sagittal suture and the sagittal suture itself, corresponding, in fact, with that area of the vault usually referred to as the vertex. The thickness of the parietal bone is fairly uniform from base to eminence, but decreases at first gradually and then more rapidly from eminence to sagittal suture. This decreasing thickness of the portion comprising the vertex is an important factor in the mechanism of elevation in so far that it helps to determine the direction of movement when a force is applied to the eminence. The vault is raised not by bending, but by unbending (Fig. 1).

The parietal bones were removed from the skull of a recently dead full time foetus

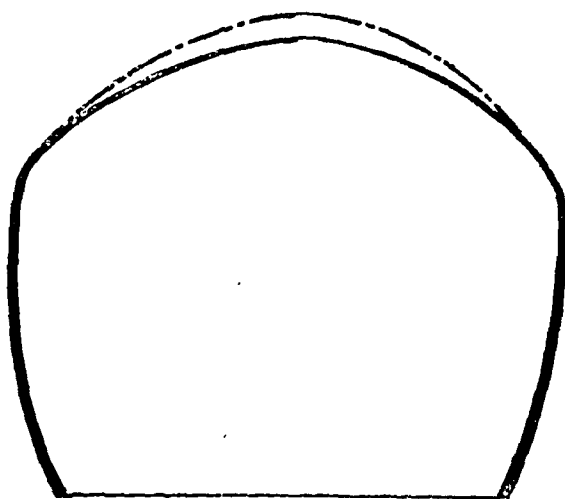


FIG. 1.

Coronal section through parietal eminences. The uninterrupted line indicates unmoulded contour. The chain-dotted line shows effect of applying force to each eminence to the limit of normal moulding, i.e. without producing significant diminution of bi-parietal diameter.

weighing between 7 pounds and 8 pounds. The bones examined were from breech cases, and had not been subjected to any moulding by the natural forces. The membranous suture tissue was pared from the edges of the bone, which was then washed free of blood in saline and dried with absorbent material. One bone was placed on a sheet of paper, concave surface downmost, and its outline traced with a pencil. The bone was steadied with the other hand, and care taken to make no pressure upon it. Weights ranging from 1 pound to 14 pounds were then placed on the convex surface, and the outline traced with each increment. A typical result is shown in Fig. 2. The straightening-out movement is confined to that part of the bone lying between the tuberosity and sagittal suture, and resulted in an average increase in length of about $\frac{1}{8}$ inch (5 mm.) in the small series tested. It is of interest

to note that a pressure of 14 pounds over each parietal eminence would correspond approximately to the compression force which might be expected to result from a traction force of about 60 pounds with the forceps applied to the sides of the head.

The parietal eminence is equidistant from the bregma and the posterior fontanelle, but lies nearer to the mid-point of the sagittal suture than to either of these points. This, combined with the fact that the bone is not only convex from side to side but from back to front, results in an increase greater along the anterior and posterior margins than along its middle.

The greatest increase was obtained with weights between 4 pounds and 7 pounds.

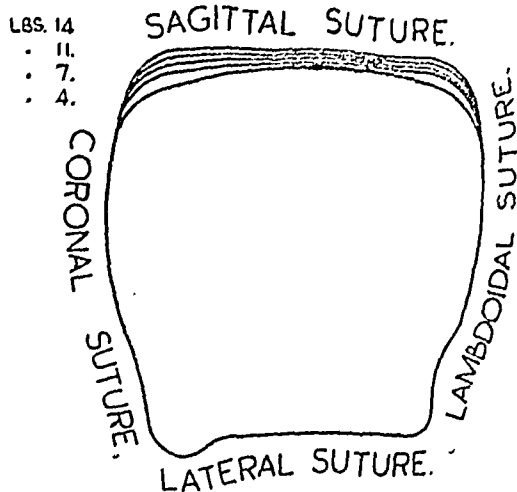


FIG. 2.

Tracing of parietal bone showing effect of placing weights over the eminence. Note that the elongation takes place in the upper vertical portion of the bone. There is no alteration in antero-posterior measurements, nor is there any movement at the lateral suture.

Additional weights up to 14 pounds produced little more increase. There can be no other mechanism contributing to this increase of the mento-vertical diameter since the temporo-parietal sutures and the

sutures of the base are much too firmly bound to yield without rupture. Moloy¹, in his radiological study of moulding, has found separation along this lateral suture in cases of severe moulding, a finding which must appear as uncommon to anyone who has attempted to measure the force necessary to effect this separation. Some increase in intracranial tension may be a factor promoting elevation of the vertex, but it is not possible to demonstrate this. The maximum increase in the mento-vertical diameter would seem to be only about $\frac{3}{8}$ inch (5 mm.). It would appear, therefore, that the displacement of cranial content produced by the inward movement of the occipital and frontal bones is compensated for by an increased volume represented by 2 wedge-shaped areas extending the length of each parietal bone, with a base $\frac{3}{8}$ inch (5 mm.) at the sagittal suture and the apex at the lateral margin of the vertex. There is no reliable volumetric method of comparing the displacement with the compensation, but the impression is gained that they must be about equal.

There are certain obvious fallacies in measuring parietal elevation in the way described above. That it gets very near to the truth can be shown by fixing the foetal head against resistance and applying the blades of the forceps to the sides of the head. Traction forces between 60 pounds and 70 pounds increase the mento-vertical diameter by about $\frac{1}{4}$ inch (6 mm.).

Limitations of parietal elevation. In an interesting paper describing antero-posterior compression of the foetal head, Milne Murray writes: "It may safely be assumed that these (cranial contents) are practically incompressible and that if their containing space is limited in one direction a corresponding expansion must be found for them elsewhere. This expansion is undoubtedly provided by an elongation of the skull in a vertical direction." He

further believed that the elongation was proportionate to the compression. By screwing up clamps placed over the occiput and the face he had established experimentally that the antero-posterior diameter could be reduced from $4\frac{1}{2}$ inches (10.8 cm.) to 3 inches (7.6 cm.) without affecting the biparietal diameter. At the limit of reduction one eye protruded from its socket, but he did not appear to regard this as a compensatory mechanism to extreme force, which, in fact, it is, and is also evidence of the inadequacy of mento-vertical elongation to compensate excessive antero-posterior diminution. There can be little doubt that vertical elevation is a limited mechanism and affords very little margin before compression of the cranial contents begins.

If antero-posterior compression is carried out experimentally with a stricter regard for the conditions pertaining to labour in cases of flat pelvis, the results are rather different from those obtained by Milne Murray. If we assume, as we are entitled to, that in the mechanism of labour in cases of flat pelvis there is also a compression force in the transverse diameter of the head, and that, because of the lateral shift of the head, this force falls anterior to the bi-parietal diameter, the conditions can be fairly accurately reproduced. When the head is compressed transversely and anterior to the bi-parietal diameter, moderate antero-posterior compression fails to produce any telescoping effect, and this is due to the fact that the side to side compression slightly reduces the bi-temporal diameter so that when antero-posterior compression is applied the edges of the frontal and parietal bones impinge upon each other in the lower parts of their suture lines, and so greatly limit any movement calculated to reduce the antero-posterior diameter except by the use of very great force. Moloy¹ describes this locking effect

occurring, not only anteriorly but also posteriorly, along the lambdoidal suture. In the writer's own experiments, it occurred only if the transverse compression were applied first, as it probably is in the circumstances of labour described above. The manner in which the frontal and parietal bones articulate favours antero-posterior movement.

An interesting and significant observation was made when carrying out this experiment. When antero-posterior compression is begun, the first movement of the frontal and occipital bones is to bend inwards, and when the apices of these bones have become depressed to the extent of about $\frac{1}{4}$ inch (6 mm.) continued compression causes them to drag on the parietals, and the edges of these bones can be seen to be pulled down. This drag on the parietals must indicate the limit of safe antero-posterior compression.

Excessive inward movement of the occipital and frontal bones tends to prevent

elevation of the vertex by dragging on the parietals so that in a well-balanced response to compression both movements will share equally the intervening membranous suture and each movement will be stopped simultaneously when the suture is fully stretched, or there will be interplay below this level (Figs. 3 and 4). It is probable also that

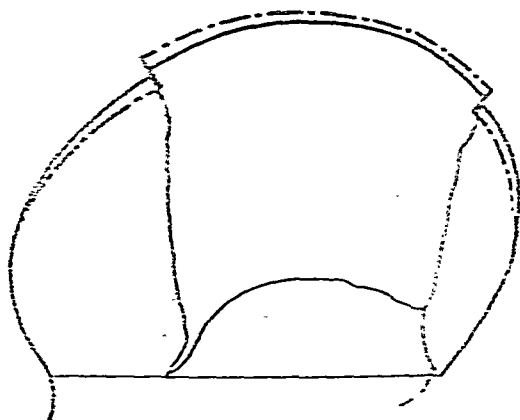


FIG. 4.

Maximum normal moulding. The uninterrupted line indicates unmoulded skull contour. The thin-dotted line shows depression of occipital and frontal bones with elevation of parietal. The maximum suture is fully stretched and equally shared by each movement.

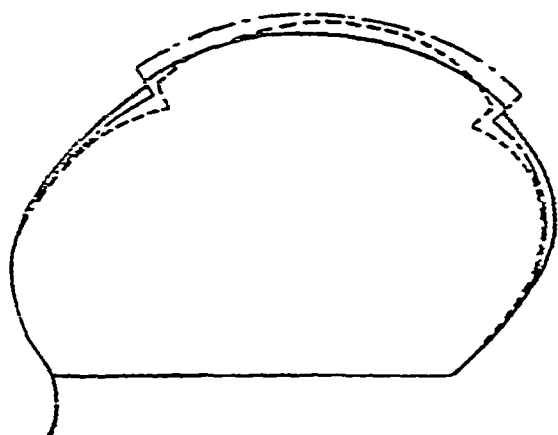


FIG. 3.

The uninterrupted outline shows normal skull contour. The dotted outline represents excessive moulding—the parietal bones are being pulled down by the inward bending of the occipital and frontal bones. The chain-dotted outline shows theoretical effect of reducing compression force and restoring normal moulding effect by releasing tension on membranous sutures (Diagrammatic).

pressure over the convexities of the frontal and occipital bones will cause some slight lengthening of these bones, but, with the head fully flexed these convexities lie above and below the main incidence of compression so that they are not likely to respond to the same degree as the parietals. At the same time, it must be observed that, with the head fully flexed, the incidence of compression will fall chiefly on the upper mobile portions of the frontals where they form the anterior angle of the braggia, so that depression is easily accomplished, and is in some respects the favoured movement. It is probably for this reason that the parietals are often brought close together

along the anterior end of the sagittal suture, and where the head has been exposed to relatively great compression force there is commonly slight overlapping here. In such circumstances, overlapping of the parietal bones along the sagittal suture must indicate that reduction of the cranial cavity has begun.

In the case of the occipital bone, the main incidence of compression will fall below the tuberosity and will tend to lengthen the bone by straightening out the curve. The pull on the parietals along the lambdoidal sutures would therefore only begin some time after the anterior pull had begun. Approximation and even slight overlapping of the parietal bones is much more easily produced at the anterior end of the sagittal suture than at the posterior end.

There was one other observation made which is not without interest. When pressure is made on the occipital bone so that it is depressed inwards, the apex of the bone "claws" down the tentorium. Very great force is required to effect this experimentally, however. Nevertheless, it is possible that, in some cases, particularly where a wide membranous suture allows greater mobility of the bone, powerful suprapubic pressure on the aftercoming head or its extraction by excessive traction on the shoulders may give the bone sufficient impetus to tear through the junction of falx and tentorium. It is interesting to note in this connection that, when compression-force is so great as to produce excessive moulding, the parietal bones are anchored down by the inward movement of the frontal and occipital bones. In these circumstances, intracranial tension will continue to rise with the compression-force, and as a first effect of the 2 opposed forces—the downward pull exercised by the occipital and frontal bones and the upward thrust of rising intracranial tension towards the least resistant part of the skull, together

with the effect of bi-parietal compression—bending of the vertex will occur. While this mechanism may contribute to the tearing of the dural septa, it is not the whole story, for tears are very difficult to produce experimentally.

It is not uncommon to see foetal heads with appearances of great elongation. Recently the writer delivered a rickety dwarf after a prolonged and difficult labour. The foetus was stillborn and the head greatly elongated, particularly on the left side. On cutting the scalp transversely from ear to ear through the summit of this convexity the elongation was found to be due chiefly to the accumulation of blood clot and serous fluid between the scalp and the skull. There was no haemorrhage beneath the pericranium, nor was the scalp infiltrated with blood or oedematous fluid.

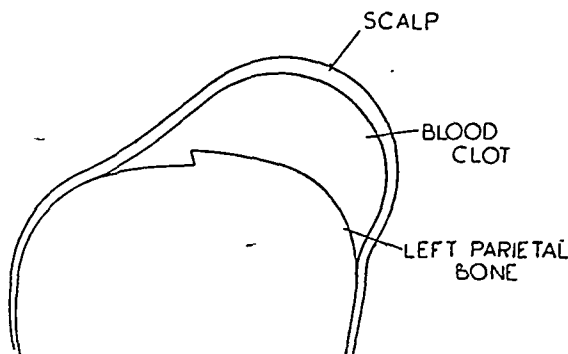


FIG. 5.

Coronal section through parietals showing conditions present in a case where great elongation of the skull was apparent. Note that the blood clot and serous fluid lie between the scalp and the pericranium. The scalp tissue itself is little changed.

The left parietal bone was raised above the level of the right along the sagittal suture, this being more pronounced anteriorly than posteriorly and the maximum elevation estimated at $\frac{3}{8}$ inch (5 mm.). There was slight overlapping of the bones anteriorly,

but they tended to diverge posteriorly. Slight overlapping was also present along the frontal and lambdoidal sutures, and was probably no more than $\frac{1}{8}$ inch (1.5 mm.). The falx and tentorium were intact and no macroscopic lesion found in the brain. This case illustrates the possibility of mistaking the effects of injury for those of moulding (Fig. 5).

In conclusion, it should be stated that the observations described in this paper refer to the full-time foetus weighing between 7 pounds and 8 pounds. There is some

evidence that postmaturity greatly reduces the movement of parietal elevation.

I am indebted to Professor R. W. Johnstone for criticism and advice. This paper is published through the courtesy of Dr. Johnstone, Medical Officer of Health, Greenock.

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Acute Inversion of the Uterus

BY

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CHISHOLM¹ has recently reported a case of acute inversion of the uterus, and makes interesting comment thereon. It is obvious from all statistics, and from the personal experience of all obstetricians, that this condition is, as he says, "very rare and important," the incidence being variously given from 1 in 10,000 to 1 in 100,000 deliveries. As a consequence of its rarity the diagnostic standards laid down in many textbooks may be misleading, and there may be much uncertainty regarding its treatment. I propose to report 2 cases which I personally have observed, and to make certain comments on the condition in the light of my experience.

Case 1. 2-para, age 22 years.

Obstetrical History. First pregnancy had terminated in January 1940 in the spontaneous birth of a full-time living child. Third stage of labour lasted 35 minutes, and was normal. On the 4th day she showed a rise of temperature which was found to be due to a haemolytic streptococcal infection. This came rapidly under control, and she was discharged well upon the 18th day.

Second confinement. Following uncomplicated 1st and 2nd stages of labour, a living child weighing 6 pounds 5 ounces was born spontaneously at 1.20 p.m. I happened to be in another part of the labour ward at the time of the birth, and so was in a position personally to observe subsequent happenings. The 3rd stage of

labour was uneventful for 25 minutes—in this clinic "control" of the fundus is forbidden in the 3rd stage, the fundus is "observed." No attempt was made to express the placenta. My attention was now called to the patient, as she had had a small amount of vaginal bleeding with which she passed into profound shock. A blood-pressure reading was not obtainable. The possibility of inversion was immediately considered, but as the uterus was considered to be normal on abdominal palpation, and as nothing abnormal was visible at the vulva, this diagnosis was regarded as improbable, and it was decided to proceed with anti-shock treatment, and await developments. The usual treatment was at once available, the patient getting serum 1 pint, rapidly followed by a pint of blood by drip. She showed signs of recovery which were progressive for 45 minutes; the uterus still appeared normal to abdominal palpation, the placenta was still retained, and there was no further haemorrhage. She now cried out with severe abdominal pain, and passed quickly into shock so profound that her condition seemed hopeless. Palpation of the uterus did not even now suggest inversion of the uterus, and there was still nothing visible at the vulva. The uterus felt *per abdomen* much as it had felt originally. No sign of "cupping" could be found, even though it was deliberately looked for, and the patient was unusually thin.

Vaginal examination was now made; it

revealed a complete inversion of the uterus. (In the Chisholm case the author speaks of complete inversion as including also prolapse. O'Sullivan² in a recent article uses the term complete inversion in a similar manner, which I submit is incorrect. In this case there was no prolapse.) The placenta was attached to the fundus and there was no bleeding. I made an attempt to replace the uterus with the placenta *in situ*, but as this presented some difficulty I removed the placenta, and was then able to reduce the inversion easily. The patient's condition showed immediate improvement following reposition. She very soon regained consciousness, and seemed to be out of immediate danger; anti-shock measures were continued, another pint of blood being administered. Full doses of sulphonamides were started. Convalescence was unsatisfactory, the patient being febrile from the 2nd day of the puerperium, and symptoms of diabetes insipidus became apparent from the 6th day. She died on the 10th day.

Postmortem examination was made. The uterus was found in good position, and showed evidence of localized inflammatory processes. Complete necrosis of the anterior pituitary had taken place with partial necrosis of the posterior lobe.

For an account of the diabetes insipidus and pituitary necrosis found in this case see the following article on page

Case 2. 3-para, age 34.

Obstetrical History.

First confinement, April 1939. Forceps delivery; severe postpartum haemorrhage; manual removal of placenta; puerperium afebrile.

Second confinement, June 1940. Spontaneous; 3rd stage normal; puerperium normal.

Third confinement. Spontaneous de-

livery after easy 1st and 2nd stages of labour. Following the birth of her baby the patient quietly rested for 15 minutes; there was then a slight vaginal blood-loss with which she passed into profound shock, blood-pressure reading being unobtainable. My assistant, Dr. T. Boland, who had been present since shortly before the birth of the baby, initiated anti-shock measures at once, and telephoned me. He reported the patient's condition and was quite definite that the uterus appeared quite normal to palpation, and that nothing abnormal was apparent at the vulva, nor was any haemorrhage taking place externally. I instructed him to, at once, make a vaginal examination, and to replace the uterus should he find it inverted—to await my arrival would have involved about 15 minutes delay. He found that complete inversion had taken place, and that the placenta was attached over the inverted fundus. He removed the placenta and reduced the inversion.

On my arrival, 15 minutes subsequent to the telephone call, I found the patient conscious, still shocked, but her systolic blood-pressure was now 80 mm. She was given a pint each of serum and blood and was fully recovered in 24 hours time. Sulphonamides were administered in the puerperium, which was uneventful.

DISCUSSION.

Aetiology. Most writers agree that a fundal insertion of the placenta is a necessary predisposing factor in inversion of the uterus. In both the cases herein reported the placenta was so situated.

Given a fundal insertion of the placenta various determining causes have been cited for the actual occurrence of the condition:

- (a) An atonic state of the uterus, during which state pressure is made upon the fundus or traction is exerted on the cord.
- (b) Precipitate labour whilst the patient is

in the erect position. (c) Tumours at the fundus uteri. In the 2 cases here reported it is certain that none of these determining causes were present, and that both cases were determined by a normal uterine contraction in the 3rd stage of labour.

Ordinarily such a contraction will crowd the placental cotyledons together and will so reduce the size of the placental site that separation of the placenta will take place towards the centre of its site of insertion. If, however, there is any factor which interferes with this central separation of the placenta the result of the uterine contraction will be to invaginate the placenta into the uterine cavity and to carry with it the placental site to which it is firmly attached. Such interference with placental separation could be brought about by localized atony at the placental site—which appears to me a most improbable occurrence; or by abnormal adhesion of the placenta to its site—this latter state of affairs could be brought about by minor degrees of placenta accreta. Such localized areas of placenta accreta are now generally recognized. It is not my purpose to discuss the causation of placenta accreta—but it is of interest to note that in both of the cases here reported 2 of the usually cited predisposing conditions for placenta accreta were present—the one had a severe infection at her 1st confinement, and the other had a manual removal of the placenta.

Whilst, therefore, it is of course possible that gross mismanagement of the 3rd stage of labour can cause the condition, the extreme rarity of the accident would rather suggest that it is just as often of spontaneous occurrence.

Diagnosis. Williams stated long since that inversion of the uterus must always be suspected and looked for when unexplained shock arises in the 3rd stage of labour. This simply means that the patient should be

examined at once vaginally. The history of the 2 cases here reported bears this out very clearly. In the 1st and fatal case, the failure to note any "cupping" of the uterus in an exceedingly thin woman tempted one to treat the shock on the assumption that inversion had not taken place whereas, in fact, an incomplete inversion had already occurred. It did not proceed to complete inversion until by our anti-shock measures we had brought the patient round to such a condition that her uterus became active again. It was then too late. We were still able to recover the patient from her immediate shock, but the pituitary had been destroyed.

Treatment. There appears to be much difference of opinion as to how these cases are to be treated. All will agree that the shock must be dealt with at once, but many will hold that operative interference must not be undertaken until such measures have shown or have begun to show a result. This attitude seems to be based upon the treatment of surgical casualties. But the conditions are not analogous. In the casualty, operative interference usually will be called for to prevent toxic absorption from damaged or crushed tissue, or to replace broken bones etc, that is in such cases the inflicting agent of the primary shock has already ceased to act. In the case of the acutely inverted uterus it is certainly arguable that the "inflicting agent" of the shock is still in action, and will remain in action for a considerable time unless the uterus is replaced. The shock would appear to be due, as Chisholm says, to the stretching of the nerves in the broad ligament and peritoneum which have been dragged into the inverted uterus. The effect of putting these structures on the stretch is well known to all obstetricians. It is, therefore, part of the treatment of the shock in these cases to remove the cause of

the shock, that is, to restore the uterus to its normal position as gently and quickly as possible. My experience in the 2 cases reported would certainly suggest that such restoration of the uterus is the most important part of the treatment.

This restoration can be most easily carried out after removal of the placenta. Undoubtedly, if restoration could be accomplished easily with the placenta *in situ* the possibility of infection would be lessened, but this presupposes that such a placenta will then leave the uterus without manual intervention. I think very few obstetricians would have the temerity to await normal separation in such a case.

I have been much impressed by the method of replacement described by O'Sullivan in the article already cited—replacement by the hydraulic pressure exerted through a douche. It will be noted that in both the cases in which he used the method the placenta had already been removed. If a douche is ready I think this simple method should be at once tried, but if the preparation of the douche entails any delay I think it probably wiser to proceed manually and at once.

SUMMARY.

Two cases of spontaneous inversion of the uterus are reported.

In both the inversion was complete without prolapse. In both "cupping" of the uterus was not noted by abdominal palpation although the patients were thin.

In the 1st case the absence of the 2 signs above mentioned prompted delay in vaginal examination and reduction. It is argued that this delay was responsible for the death of the patient.

In the 2nd case vaginal examination was made at once although both signs were absent, and immediate reduction was carried out.

From the morbid anatomy of the condition, and from the experience gained in these 2 cases it is argued that such immediate reduction is the most important part of the treatment of the shock resulting from this accident.

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Diabetes Insipidus in Association with Postpartum Pituitary Necrosis

(A report of two cases)

BY

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and

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IT is now established that postpartum ischaemic necrosis of the anterior pituitary is a relatively frequent complication in cases where delivery is attended by a severe degree of collapse. An extensive literature has accumulated dealing with the subject and within recent years the work of Sheehan and Murdoch¹ has contributed much towards the elucidation of the problem. Sheehan notes that the collapse in a large proportion of cases is due to haemorrhage, though this is not always so, and in one of the cases here reported haemorrhage had obviously no aetiological rôle in the production of the pituitary necrosis. Patients in whom the lesion occurs may die soon after clinical signs of the necrosis are first manifest or they may survive for years. In the latter case one expects the development of a clinical picture pointing to a chronic state of anterior pituitary insufficiency, and in fact the more severe cases show all the characters of the syndrome generally referred to as Simmonds's disease. In the original description of this condition, Simmonds² reported a shrunken and almost entirely fibrosed pituitary occurring in a woman aged 46 years who displayed marked emaciation, a subnormal temperature, and in general an appearance suggesting a prematurely senile state. The autopsy revealed that a very large proportion of the anterior, middle and posterior lobes of the pituitary had been destroyed. The clinical condition could be related to the birth of this woman's fifth child. Following that delivery she had suffered a severe puerperal infection. Simmonds therefore supposed that a septic necrosis had occurred in the pituitary.

Since that first report many authors have described cases of this condition and its relation to parturition has been shown, though it is now agreed that collapse rather than infection at the time of delivery is the determining factor in its occurrence. Consequently, in a careful follow-up of 128 cases in which collapse (for the most part associated with haemorrhage) had occurred at the time of delivery, Sheehan was able to demonstrate that in no fewer than 41 cases which survived there appeared subsequently symptoms which suggested strongly a greater or less degree of anterior lobe pituitary necrosis. In a reverse follow-up in 15 cases of parous women exhibiting clinical evidence of hypopituitarism he found that in 13 of these cases severe haemorrhage had complicated the preceding delivery. He correlated the severity of symptoms with the degree of collapse which had occurred.

The striking clinical feature of the two cases reported in this paper was the occurrence of an extreme degree of polyuria and the finding at autopsy of necrosis in both the anterior and posterior lobes of the pituitary body. The occurrence of symptoms of diabetes insipidus in association with postpartum necrosis of the pituitary has not previously been commented on.

CASE REPORTS.

Case 1. Booked case. 2-para, aged 22 years. Acute inversion of the uterus.

Following spontaneous delivery of a living child acute spontaneous inversion of the uterus occurred. At no time did the patient suffer from haemorrhage. The inversion was at first partial. With this partial inversion she passed into profound shock, a blood-pressure reading being unobtainable. Treatment of the shock was at once instituted—a vaginal examination was not made at this stage. About 45 minutes later, when her general condition had improved considerably, she cried out with pain and passed into shock so profound that her condition seemed hopeless. Vaginal examination now revealed a complete inversion of the uterus. The inversion was reduced. Following reduction her condition showed improvement and she soon appeared to be out of immediate danger. Convalescence was, however, unsatisfactory—from the 6th day of the puerperium until her death on the 10th day she showed *inter alia*, clinical evidence of diabetes insipidus. Her output of urine in these four days was 916 fluid ounces, that is 229 ounces per day. In the light of the postmortem findings the clinical features which interest us here are (1) profound and prolonged shock without haemorrhage, and (2) polyuria and polydipsia,

The autopsy revealed the following findings: On opening the cranium the cerebrum appeared normal on inspection and on macroscopic section. The pituitary was approximately normal in size. The cerebellum was normal.

The lungs were pale in colour and macroscopic section showed no pathological feature. The heart was normal.

The abdominal viscera appeared normal except for slight congestion in the kidneys. It was found that the inversion of the uterus had been completely reduced. On incising the uterus a patchy purulent exudate was found covering the mucosa except in a few smooth and shiny areas. The placental site was evident at the fundus but did not present any gross evidence of infection. There was a small haematoma at the right cornua.

The uterus and its adnexae, portions of the lungs, myocardium, liver, spleen, kidneys, pancreas and the entire pituitary gland were removed for microscopic examination.

Following is the report on the histological findings:

Liver. Sections show little or no pathological change. The liver cells may be somewhat shrunken and the sinusoids dilated.

Spleen. Shows some congestion.

Kidneys. Sections show very little pathological change. Here and there the lining cells of an occasional tubule are degenerate and hyaline casts are present. There is some slight old-standing fibrosis near the pelvis.

Uterus. This postpartum organ was enlarged. It was lined with necrotic tissue. Sections show this necrotic tissue beneath which there is a zone infiltrated with pus cells and chronic inflammatory cells.

Pituitary. This was about normal in



FIG. 1.

Saggital section through the pituitary gland showing widespread necrosis of the pars anterior. Haematoxylin and eosin.

Photomicrograph $\times 12$

S. & G.



FIG. 1A.

Photomicrograph $\times 190$ of pars nervosa showing degeneration and
loss of nuclear staining.
S. & G.



FIG. 2.

A coronal section of pituitary gland showing massive necrosis of pars anterior. The arrow indicates the portion of the pars nervosa shown in Fig. 2A. Haematoxylin and eosin.

Photomicrograph $\times 10$

s. & G.

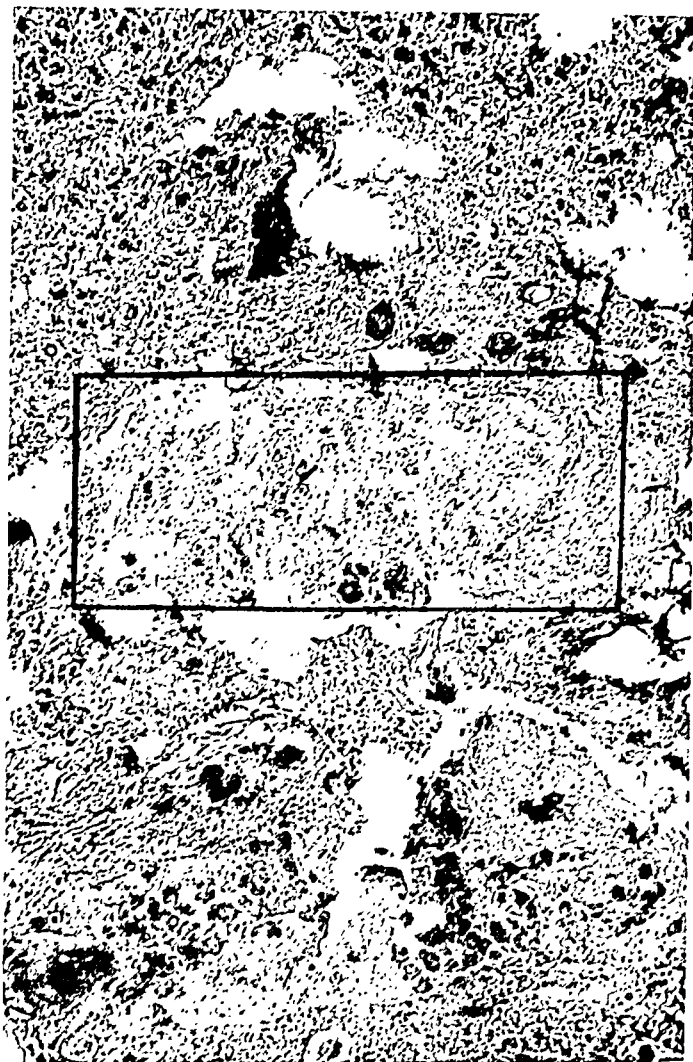


FIG. 2A.
Showing necrosis of the infundibular portion of the pars nervosa.
Photomicrograph $\times 50$.
S. & G.

size, measuring 10×8 mm. Sections show that there is massive necrosis of the anterior lobe. The outline of the cells forming the alveoli of the anterior pituitary are still visible, but they are entirely necrotic and the nuclei have disappeared. The inter-alveolar septae are still visible. Only occasional groups of healthy cells remain about the periphery of the gland. The posterior lobe shows a partial degenerative change with loss of the normal compact structure of the neuroglia and a notable deficiency of pituicytes in the degenerate area. It is to this latter lesion that attention is particularly directed in view of the polyuria which was a striking feature in the clinical course of this case. See Figs. 1 and 1a.

Case 2. Emergency admission; 4-para; aged 34 years. Combined accidental haemorrhage.

This patient, who had not received antenatal care, was found unconscious in a field near her home on a cold, wet day. How long she had so lain is not known. She was taken to a district hospital, where, shortly after admission, she had an eclamptic fit. She was then transferred some 60 miles to the National Maternity Hospital, Dublin.

On admission to this hospital the patient was conscious, very cold, and suffering from some shock. She complained of intense headache. Examination showed her to be about 36 weeks pregnant. Slight vaginal bleeding was taking place. Oedema was marked but not gross; 8 ounces of urine were obtained by catheter. Albumin was present in the urine in large amount (boiling solid). Blood-pressure reading shortly after admission was 130/80. The uterus was tense and tender but definitely active. The cervix uteri was dilated to 3 fingers. The foetal heart was not heard. Shortly after admission the membranes ruptured and $1\frac{1}{2}$ hours later the head was on the

perineum. The patient was delivered by low forceps of a stillborn child weighing 6 pounds and 4 ounces. Third stage of labour lasted 5 minutes and the placenta was followed by a large clot.

The patient died 84 hours after delivery. Acute pulmonary oedema developed 12 hours before death. During these last 12 hours she was unconscious and incontinent of urine. In the 72 hours preceding unconsciousness she passed 593 ounces of urine, that is 190 ounces per day. She complained all this time of thirst and headache. This case presents similar clinical features to Case 1, that is (1) profound shock and (2) polyuria and polydipsia.

At autopsy the pituitary appeared slightly larger than normal for the 3rd day of the puerperium. It was of a deep plum colour. Little other abnormality was noted and the pulmonary oedema of which clinical evidence had been observed was not present in a gross degree. There was slight enlargement of the mesenteric lymph nodes. Some of the later structures, together with portions of the liver, kidneys, pancreas and the pituitary, were removed for microscopic examination.

The liver, pancreas and mesenteric glands were histologically normal. Sections from the pituitary showed an almost complete necrosis of the anterior lobe of the gland. There were a few small islets of surviving cells, but the bulk of the tissue was markedly degenerate with a very striking infiltration by polynuclear leucocytes. This leucocytic reaction was most marked in the periphery of the gland. (See Fig. 2.) Examination of the posterior lobe showed an area in which degeneration of the neuroglia and deficiency of pituicytes was observed. The appearance was similar to that noted in Case 1. (See Fig. 2a.)

In each case the postmortem examination was begun within a short time of the patient's death. As the possible existence

of pituitary necrosis was suspected in each case it was desired to obviate the occurrence of postmortem autolytic change in the anterior lobe cells. In Case 1 the pituitary was actually removed and placed in fixative within 45 minutes of the patient's death.

The occurrence of a marked polyuria in these cases is of interest in view of the fact that a lesion can be demonstrated in the pars posterior of the pituitary. It has been known for some 50 years that injection of extracts of the posterior lobe into animals produces an antidiuretic effect provided the dose is sufficiently large. Small doses tend to produce a diuretic effect presumably because the rise in blood-pressure results in increased flow through the renal filter. The precise mechanism by which the antidiuretic effect is exerted is not clear. It may be due to a vasoconstriction of the afferent renal arterioles.

Much experimental work has been carried out in an effort to decide whether the pressor, oxytocic and antidiuretic effects of extracts of the posterior pituitary are due to the action of a number of different hormones or to the manifold action of a single substance. Kamm³, Stehle⁴ and others have claimed the separate isolation of two different fractions, one having a potent pressor effect with little action on the plain muscle of the uterus and the second producing a significant contraction of uterine muscle with minimal rise in blood-pressure. These fractions have not yet been isolated in a state of crystalline purity. Of these two substances it is commonly held that the antidiuretic effect is exerted by the pressor fraction.

On the other hand certain evidence is available which suggests that only one hormone is in operation. Van Dyke *et al.*⁵ have recently reported the isolation of a single substance possessing pressor, oxytocic and antidiuretic effects.

Of the clinical disorders which can be correlated with hypofunction of the posterior lobe, diabetes insipidus is the most striking. The profuse polyuria with attendant polydipsia may be the only symptoms. The condition can be readily connected with lesions of the posterior lobe and of the adjacent hypothalamus. It appears that the polyuria resulting from ablation of the posterior lobe of the pituitary is less enduring than that which follows interference with the hypothalamus. Camus and Roussy⁶ state that the latter type cannot be controlled by injection of posterior lobe extracts. It now appears that loss of nervous control following damage to the hypothalamus determines the occurrence of hypofunction of the posterior lobe (Cushing). It is of significance that in the experimental animal the polyuria following ablation of the posterior lobe is relieved by removal of the remainder of the gland. This suggests that some action of the anterior lobe hormones is necessary in the production of the diabetes insipidus syndrome. In this connection it may be worthy of note that in the two cases here reported a small proportion of the anterior lobe cells survived.

SUMMARY.

Two cases of postpartum necrosis of the pituitary are reported. In each case both the anterior and posterior lobes of the gland showed degenerative lesions.

In each case polyuria and polydipsia were prominent features in the clinical picture.

Profound shock occurred at the time of delivery in both cases. In Case 1 this was associated with acute inversion of the uterus, and in the second case with combined accidental haemorrhage occurring in unusually unfavourable circumstances.

ACKNOWLEDGMENTS.

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A Study of Normal and Abnormal Menstrual Function in the Auxiliary Territorial Service

BY

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DURING and since the war large numbers of young women have been brought together in the Services under military control and discipline, giving unusually favourable opportunities for medical and sociological inquiries. One such inquiry into normal and abnormal menstrual function is described in this paper.

The objects of the inquiry were as follows:

(1) To obtain data regarding normal menstrual function in young women and the incidence of dysmenorrhoea and its relation to social and personal background.

(2) To ascertain whether service in the Auxiliary Territorial Service has any significant effect on menstrual rhythm, and whether there is any correlation between such disturbance and social or personal factors.

METHOD.

Over 700 recruits and Serving Auxiliaries were personally interviewed by myself. Clinical examination was not made, but a full history was obtained of social background and general health, as well as details regarding menstrual history. The women interviewed included representatives from 12 different units, comprising officers and other ranks, and most of the main employment groups of the A.T.S.

The women talked freely and, it is believed, truthfully. A questionnaire used to record answers was so planned that the accuracy of certain statements could be

checked by others approached from a different angle. Not any inconsistency was found.

The information obtained regarding menstruation can be considered under three headings: (a) Dysmenorrhoea; (b) Irregularity of Cycle; (c) Menstrual Disorders at Entry to the A.T.S.

A. DYSMENORRHOEA.

I. Frequency and Severity of Dysmenorrhoea.

Each case was assessed by history of symptoms and the extent of interference with normal routine stated to have been caused thereby. Cases are classified as follows:

(1) Those who denied any change of normal routine associated with menstruation: (a) with no admitted symptoms; (b) with symptoms.

(2) Those who stated that they absented themselves from games and social engagements.

(3) Those who stated that they stayed away from work.

TABLE I.

	No. of cases	Percentage
Symptom free	339	47.5
Symptoms		
No change of routine	213	29.8
Absent from games, etc.	54	7.5
Absent from work ...	108	15.1
Total	714	100.0

Of those complaining of symptoms, 50.4 per cent took medical preparations habitually. Only 7.2 per cent had at any time consulted a doctor about dysmenorrhoea.

3. Relation of Dysmenorrhoea to Age.

Table II and Fig. 1 show the incidence of dysmenorrhoea in different age groups.

The percentage of symptom-free individuals

TABLE II.

	Age in years					
	Under 20	20-21	22-24	25-27	28-30	Over 30
Symptom free	45.4	38.9	42.4	43.8	46.3	64.4
Symptoms but no change of routine	35.7	36.1	32.4	35.9	33.3	23.7
Change of routine	18.9	31.0	25.2	20.3	20.4	11.9
Total	100.0	100.0	100.0	100.0	100.0	100.0
No. of cases	185	90	262	64	54	59

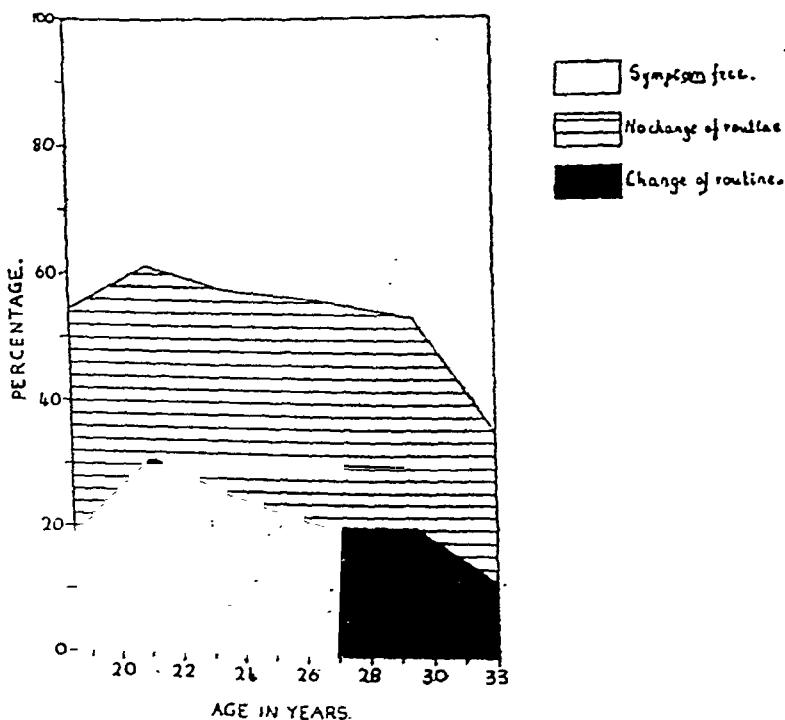


FIG. 1.

Incidence of dysmenorrhoea by age.

2. Comparison between Recruits and Serving Auxiliaries.

Not any significant difference was found between recruits and serving auxiliaries as to incidence or severity of dysmenorrhoea.

duals is minimal in the 20-21 age group, and thereafter rises with age. The high incidence of symptom-free individuals over 27 years of age is seen to be statistically significant in the following table, while the

difference between the Under 20's and 20-27's is not significant.

TABLE III.

Age in years	Per-centage symptom free	Difference from age group 20-27	Standard error of difference	Ratio diff.: S.E.
Under 20	45.4	3.6	4.4	0.8
20-27	41.8			
Over 27	55.8	14.0	5.3	2.7

The incidence of interference with normal routine also falls off significantly with age.

TABLE IV.

Age in years	Change of routine free	Difference from age group 20-27	Standard error of difference	Ratio diff.: S.E.
Under 20	18.9	6.8	3.6	1.9
20-27	25.7			
Over 27	15.9	9.8	4.0	2.5

It appears, therefore, that the frequency of dysmenorrhoea decreases gradually with age, and markedly after 27 years. An enquiry into menstruation in schoolgirls carried out by the London Association of the Medical Women's Federation¹ found an increase in frequency of dysmenorrhoea throughout the school age. The percentage of symptom-free girls fell from 72 per cent

in the early age groups to 27 per cent in the older groups. An exact comparison with the present inquiry is not possible as the figures are not given by age but by length of menstrual history. Nevertheless, from the pooled results of both these inquiries, it appears that the incidence of dysmenorrhoea rises until the early 20's, and then begins to fall off. This finding also accords with the generally held clinical impression that girls "grow out" of their dysmenorrhoea.

4. Relation of Dysmenorrhoea to Employment Group.

At the A.T.S. Training Centres much effort is made to place each recruit in the employment group for which she is best fitted physically, intellectually and temperamentally. Any differences, therefore, between incidence of dysmenorrhoea in different employment groups might be explained either by the nature of the work or by differences within the individuals. A group of 555 Serving Auxiliaries have been analysed with reference to employment as follows:

(1) *Operational.* Anti-Aircraft Command. (a) Indoor—Personnel employed on underground signal duties; (b) Outdoor—Personnel employed on A.A. gun sites and searchlight sites.

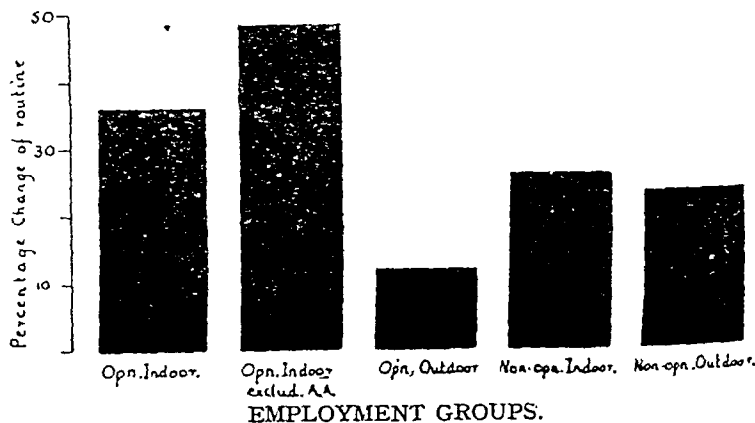


FIG. 2. Incidence of disabling dysmenorrhoea in different employment groups.

(2) *Non-operational.* (a) Indoor—Cooks and orderlies, storewomen, clerks and administrative personnel; (b) Outdoor—Storewomen and drivers.

Fig. 2 shows the incidence of dysmenorrhoea of sufficient severity to cause change of normal routine in the 4 groups given above.

The lowest rate of dysmenorrhoea is seen to be in the outdoor operational group. Girls selected for this work have to be of a high standard of physical fitness.

Table V compares the incidence of dysmenorrhoea in this group with the mean incidence among the rest, and shows it to be significantly lower.

TABLE V.

Employment	Percentage change of routine
Operational, outdoor	11.7
Rest	26.5
Difference	14.8
Standard error of difference ...	3.6
Ratio difference : S.E.	4.1

The highest incidence of dysmenorrhoea is seen in the indoor operational workers. The difference between this group and the mean of the rest is just significant, being 14 per cent, with a standard error of difference of 7. The auxiliaries in this group, though all employed on similar work, are not all selected in the same way. The group can be divided into 2:

(1) A.A. personnel who have to conform to the physical standards of outdoor operational workers and who may be posted to this type of indoor work, or more commonly to A.A. sites.

(2) Personnel attached to Royal Corps of Signals. These latter need not attain the same high standard of physique and will always work indoors, whether on operational or non-operational duties.

For both groups the work is exacting and trying, particularly so at the time

of this inquiry, which was towards the end of the flying bomb period, but owing to a different shift system the latter group have longer hours underground, more disturbed sleep, and appeared to worry about their work a good deal more than the A.A. girls.

The following table shows the number of cases in each section complaining of dysmenorrhoea:

TABLE VI.

	A.A. Percentage	Signals Percentage
No change of routine ...	16 (84.2)	16 (51.6)
Change of routine ...	3 (15.8)	15 (48.4)
Total	19 (100)	31 (100)

It is obvious that it is the signal personnel who contribute largely to the high incidence of dysmenorrhoea amongst indoor operational workers. Comparing these with the rest of the total sample, the following table is obtained:

TABLE VII.

	Percentage change of routine
Signals	48.4
Rest	21.6
Difference	26.8
Standard error of difference ...	9.2
Ratio difference : S.E.	2.9

The A.A. girls employed on indoor signal work have an incidence of dysmenorrhoea of 15.8 per cent. This is not significantly different from the incidence in A.A. girls employed outdoors, which is 11.7 per cent.

A further sub-division of the total sample was made into sedentary and non-sedentary workers.

TABLE VIII.

	Percentage no change of routine	Percentage change of routine
Sedentary workers	73.6 ± 5.6	26.4 ± 5.6
Non-sedentary workers	78.4 ± 4.6	21.6 ± 4.6

There appears to be no difference between these two groups. This section shows that in the studied sample, good physique and general health are associated with freedom from symptoms, whilst anxiety arising from the nature of employment may be a factor in aggravating dysmenorrhoea.

5. *Relation of Dysmenorrhoea to Rank.*

Table IX and Fig. 3 show the incidence of dysmenorrhoea according to rank.

As age is known to have an effect on the incidence of dysmenorrhoea, and the average age of the officers is higher than that of the rest, a correcting factor has been applied to the figures for officers. (For method used, see Section C.2. Relation of amenorrhoea to size of family.) The last column now shows what the rate in officers would be if the age composition of this

group were the same as that of the total sample. The incidence of disabling dysmenorrhoea is slightly higher amongst officers than amongst the rest, though not significantly so.

The incidence of complete freedom from symptoms, however, is also highest in the officer group. This discrepancy is intelligible if we assume that officers in giving a history might be more apt to minimise symptoms.

TABLE IX.

	Officers	Cadets and N.C.O's	Privates	Officers corrected for age
Symptom free	57.1	54.1	40.8	57.5
Symptoms, but no change of routine	16.7	25.4	37.3	15.1
Change of routine	26.2	20.5	21.9	27.4
Total	100.0	100.0	100.0	100.0

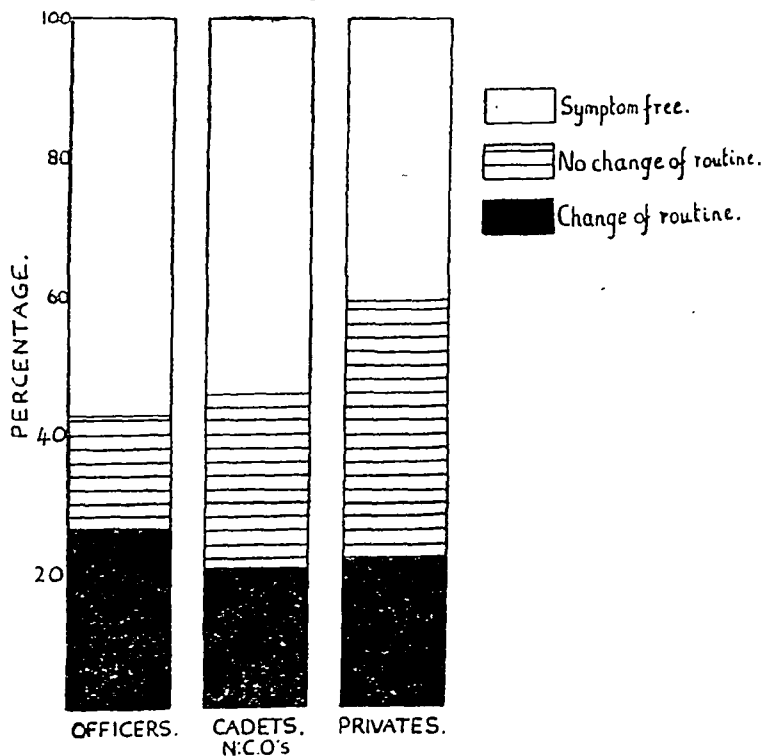


FIG. 3.

Variation in incidence of dysmenorrhoea with rank.

6. *Relation of Dysmenorrhoea to Intelligence-level.*

The selection-grading used in the Service is based on the Raven progressive matrices, which divides personnel into grades 1 to 5, grade 1 being those of highest intelligence. Since January 1942 no women of S.G. 5 have been admitted to the A.T.S., so that the figures in this group are not representative of this class as a whole. Fig. 4 represents the incidence and severity of dysmenorrhoea in the different selection grades.

The S.G. 1 and 2 groups appear to have a higher incidence of alleged freedom from symptoms; however, this is not significant and may be explained by the preponderance of officers in this group. Therefore,

if the criterion of dysmenorrhoea is taken to be freedom from symptoms, not any difference is seen between the intelligent grades.

If, however, the criticism is taken to be interference with normal routine, the S.G.'s 4 and 5 appear to have more dysmenorrhoea, as shown in Table X.

TABLE X.

S.G.	Percentage change of routine
1, 2 and 3	19.7
4 and 5	32.3
Difference	12.6
Standard error of difference ...	6.2
Ratio difference : S.E.	2.0

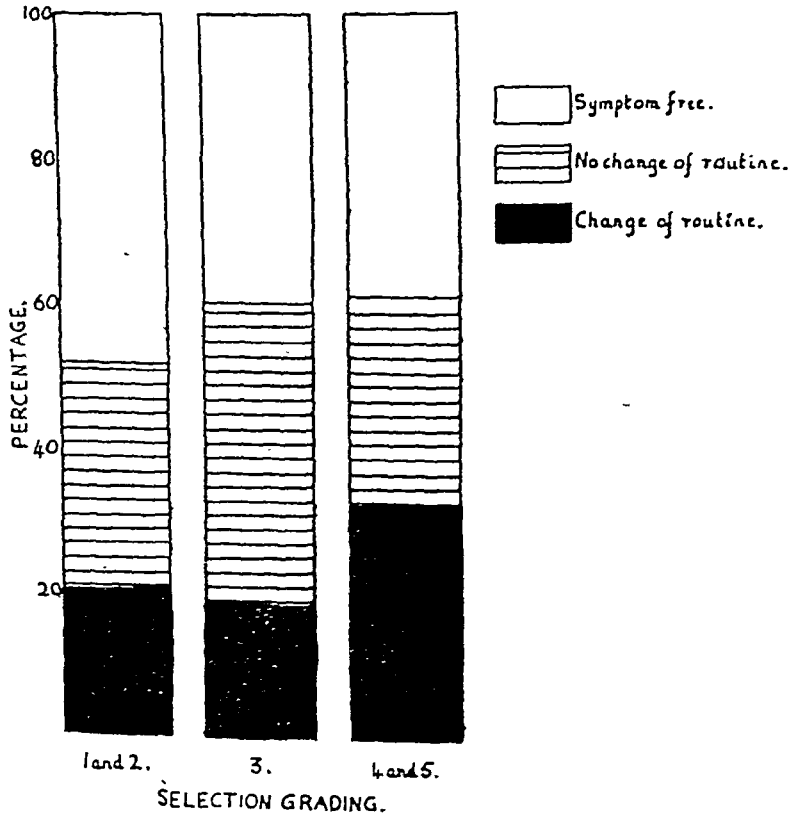


FIG. 4.
Variation in incidence of dysmenorrhoea with selection grading.

It is probable that there is not any real difference in frequency or severity of dysmenorrhoea between intelligence levels; the apparent difference is most likely due to the tendency (familiar to the Regimental Medical Officer) for the lower grades to go off work more readily if they suffer any discomfort.

7. Relation of Dysmenorrhoea to Size of Family.

It is popularly supposed that only children are more liable to dysmenorrhoea than those brought up with brothers and sisters. This point was therefore investigated.

TABLE XI.

	Percentage no symptoms	Percentage symptoms	No. of cases
Only children ...	56.0	44.0	91
Rest	46.3	53.8	623
Difference	9.8	—	—
S.E. difference ...	5.6	—	—
Ratio difference : S.E.	1.8	—	—

Only children in this series seem to be less liable to dysmenorrhoea, though the difference is not significant.

In considering the effect of home environment on only children, obviously it will operate more strongly on those who have just left home than in those who have been away from home for some time, living a communal life with large numbers of girls of their own age.

A separate classification was made, therefore, of recruits only, in Table XII, and serving auxiliaries only in Table XIII.

TABLE XII.

Recruits	Percentage symptom-free
Only children	72.0
Others	46.4
Difference	25.6
Standard error of difference ...	11.4
Ratio difference : S.E.	2.2

TABLE XIII.

Serving auxiliaries	Percentage symptom-free
Only children	52.1
Others	47.0
Difference	5.1
Standard error of difference ...	6.1
Ratio difference : S.E.	0.8

Taking recruits separately, there is a significant increase in incidence of symptom-free individuals amongst the only children. Considering serving auxiliaries only, the difference is very small. There is a difference in age distribution of only children among serving auxiliaries, compared with others, but allowing for this variation made very little difference to the original figures. The evidence is, of course, not strong enough to suggest that only children as a whole are less liable to dysmenorrhoea, though it seems certain that they are not more so.

8. Relation of Dysmenorrhoea to Exercise.

In the enquiry previously mentioned on menstruation in schoolgirls a positive association was found between freedom from symptoms and exercise. The following table shows incidence of dysmenorrhoea severe enough to interfere with routine, in those who regularly participated in some game or sporting activity, compared with that in those who did not do so. No difference is seen between the two groups.

TABLE XIV.

	Percentage No change of routine	Percentage change of routine
Exercise	78.6	21.4
No exercise	77.4	22.6

9. *Relation of Dysmenorrhoea to Other Menstrual Phenomena.*

(a) *Length of period.* The distribution into short, medium and long periods, with the incidence of dysmenorrhoea in each group, is shown in Tables XV and XVI.

TABLE XV.

Length of period	Percentage
Short: 3 days or less	15.8
Medium: 4 to 6 days	68.6
Long: 7 days or over	16.1
Total: 714 cases	100.0

TABLE XVI.

	Length of period		
	Short	Medium	Long
Percentage:			
No change of routine	80.7	80.0	71.3
Change of routine	19.3	20.0	28.7

There appears to be an increase in dysmenorrhoea in those with a protracted period. There is a difference of 8.8 per cent between the incidence in protracted cases and the mean of the rest. This is just twice its standard error and, therefore, barely significant.

(b) *Quantity of flow.* The flow was considered to be scanty when 2 towels or less were the maximum used per day, moderate when 3 to 5 towels were used, and copious when 6 or more towels were used daily. It is realised that women vary considerably in fastidiousness and standards of cleanliness, which influences the number of towels used, but this factor is likely to apply to all groups. In the A.T.S. towels are issued free, and the girl can nearly always obtain as many as she wants.

Tables XVII and XVIII show the distribution of the total sample into these

groups and the incidence of dysmenorrhoea in each group.

TABLE XVII.

	Percentage
Scanty flow	15.7
Moderate flow	72.4
Copious flow	11.9

TABLE XVIII.

	Scanty	Moderate	Copious
Percentage:			
No change of routine	83.9	77.1	66.7
Change of routine	16.1	22.9	33.3
Total	100.0	100.0	100.0

The difference assessed by change of routine is 17.2 per cent lower in the scanty than in the copious flow. This is over 3 times its standard error (5.5), and therefore highly significant. It may be that abstention from games and social occasions is due to the copious flow itself and not to dysmenorrhoea; but the clinical impression that short, scanty periods are associated with pain is certainly not borne out here.

(c) *Relation of Dysmenorrhoea to Regularity of Cycle.* See section following (B.2).

B. IRREGULARITY OF CYCLE.

Auxiliaries who stated that they did not know when to expect their next period were deemed to have irregular periods. Of the rest, some may well have experienced variations of a few days. Of the total sample, 16.2 per cent gave a history of irregularity.

1. *Relation of Irregularity to Age.*

The following table shows the age distribution of those giving a history of irregularity:

TABLE XIX.

	Age in years					
	Under 20	20-21	22-24	25-27	28-30	Over 30
Irregularity	15.2	19.8	18.5	14.5	12.8	8.5
No irregularity	84.8	80.2	81.5	85.5	87.2	91.5
Number of cases of irregularity	28	18	48	9	7	5

The incidence of irregularity is compared in 3 age groups in Table XX.

The small incidence in irregularity of cycle in the over 27 age group is only just

significant, but the trend is interesting as it is similar to that for the age distribution of dysmenorrhoea, and of amenorrhoea at entry as seen in Fig. 5.

TABLE XX.

Age in years	Percentage irregularity	Difference from age group 20-27	Standard error of difference	Ratio difference : S.E.
Under 20 ...	15.2	3.0	3.2	0.9
20-27 ...	18.2			
Over 27 ...	10.5	7.7	3.9	2.0

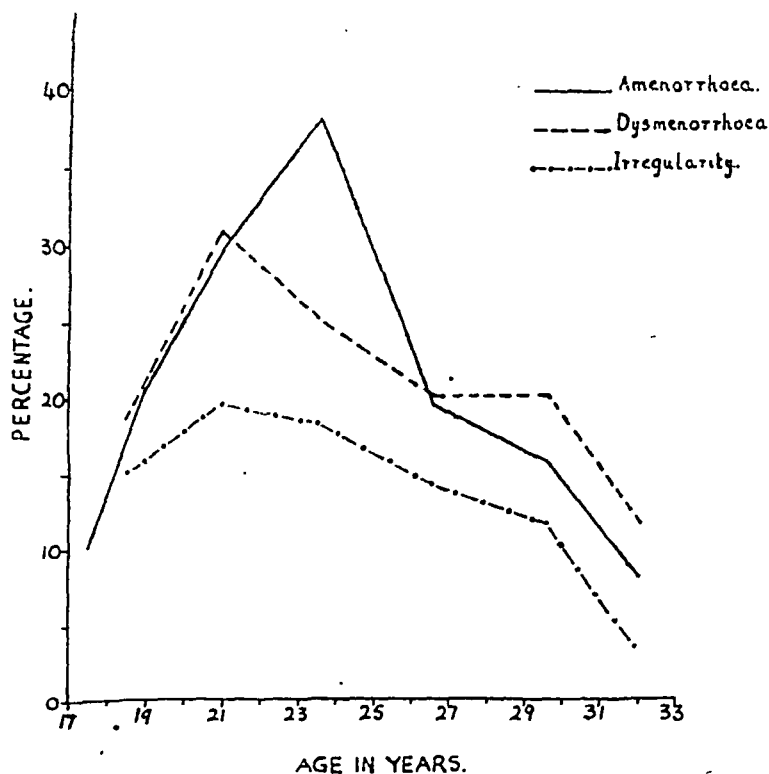


FIG. 5.
Incidence of menstrual disturbances by age.

2. *Relation of Irregularity to Dysmenorrhoea.*

TABLE XXI.

Periods	Percentage: No change of routine	Percentage: Change of routine
Regular	80.3	19.7
Irregular	60.7	39.3
Difference	19.6	
Standard error of difference	4.7	
Ratio difference : S.E. ...	4.2	↓

There is seen to be a highly significant increase in disabling dysmenorrhoea amongst those with irregular cycles.

C. MENSTRUAL DISORDERS AT ENTRY TO THE A.T.S.

The following sections on menstrual disorder immediately following entry to the A.T.S. refer only to serving auxiliaries, as the majority of recruits had been in the Service for under 2 months. The criticism may be put forward that a woman's memory of the past history of her menstrual function is highly inaccurate and that only dates set down at the time are reliable. This is certainly true of the normal function; very few women can remember accurately the dates of past periods that have occurred within what she regards as her normal limits. But if she is normally regular she will remember interruptions in that regularity, especially if associated with a definite

event, such as entering the Services. She will remember if she missed one or more periods, if she started or stopped having pain, and if she lost more or less than she had been accustomed to. It is therefore considered that such facts, elicited by questioning even some time afterwards, are reliable and probably represent a very close approximation to actual occurrence and incidence.

Data regarding amenorrhoea and other disturbances at entry, or subsequently during service, were classified as follows:

- Amenorrhoea: Cessation of menstruation over a period of longer than 56 days' duration.
- Minor disturbances lasting less than 56 days.
 - Polymenorrhoea (i.e. increased flow with decreased length of cycle).
 - Irregularity in personnel previously regular.
 - Regular change of rhythm.
 - Dysmenorrhoea in personnel previously symptom free.
 - Menorrhagia (i.e. profuse flow, usually called "flooding" by the auxiliary).

Improvement denotes less dysmenorrhoea and/or irregularity since entry.

Table XXII exhibits the proportions of these categories (a) at entry; (b) during service.

TABLE XXII.

		(a) At entry		(b) During service	
		Number of cases	Percentage	Number of cases	Percentage
Amenorrhoea	...	141	25.4	19	3.4
A	...	11	2.0	3	0.5
B	...	3	0.6	3	0.5
C	...	11	2.0	16	2.9
D	...	23	4.1	14	2.5
E	...	7	1.3	17	3.1
F	...	7	1.3	5	0.9
Improvement	...	—	—	53	9.6
No change	...	352	63.3	425	76.6
Total	...	555	100.0	555	100.0

No less than 25 per cent of the women questioned stated that they had missed at least one period on entry into the A.T.S. Some other disturbance occurred in 11.3 per cent.

During service amenorrhoea was only reported by 3.4 per cent, nearly always associated with some anxiety or emotional stress. Though figures have not been found for comparison, it seems likely that the incidence of menstrual disturbance recorded during service is no higher than would be expected in ordinary life.

rhoea lasting for longer than 12 months, all resumed the normal cycle spontaneously without recourse to medical treatment, though a few individuals did consult a medical officer. These 3 cases had all received endocrine therapy; when interviewed they were menstruating normally again.

I. *Relation of Amenorrhoea at Entry to Age.*

Tables XXIV and XXV show the age distribution of amenorrhoea at entry.

TABLE. XXIII.

		No. of missed periods													Total
		1	2	3	4	5	6	7	8	9	10	11	12	16	
Amenorrhoea at entry	...	46	26	47	7	4	5	—	2	—	1	—	1	12	141
Amenorrhoea during service	...	7	2	6	2	2									19

TABLE XXIV.

		Age in years							Total
		Under 18	18-20	20-21	22-24	25-27	28-30	Over 30	
Amenorrhoea at entry	...	10.0	20.8	29.9	38.0	19.6	16.0	8.3	25.4
No amenorrhoea at entry	...	90.0	79.2	70.1	62.0	80.4	84.0	91.7	74.6
Total	...	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
No. of cases	...	40	106	194	108	46	25	36	555

TABLE XXV.

Age in years	Percentage amenorrhoea	Difference between successive age groups	Standard error of difference	Ratio difference S.E.
Under 20	17.8			
20-24	32.8	15.0	4.2	3.6
25-30	18.3	14.5	5.4	2.7
Over 30	8.3	10.0	6.4	1.6

The next table shows the distribution of amenorrhoea lasting for varying periods of time. One missed period indicates about 56 days' cessation of menstruation; 2 missed periods about 84 days, and so on.

With the exception of 3 cases of amenor-

The difference between the age groups shown above are statistically significant in all but the over 30's. Here the numbers are very small, as few women enter the A.T.S. over this age, making the standard error proportionately larger.

2. Relation of Amenorrhoea to Size of Family.

The following table shows incidence of amenorrhoea at entry in only children and those with sibs:

TABLE XXVI.

	Percentage amenorrhoea at entry
Only children	37.0
Others	24.0
Difference	13.0
Standard error of difference ...	6.0
Ratio difference : S.E.	2.2

sample, their expected rate with the age distribution shown above would be:

$$\frac{(a_{ii} \times a_{iii}) + (b_{ii} \times b_{iii}) + \dots + (e_{ii} \times e_{iii})}{100} = 25.0$$

The age composition of only children as compared with that of the total sample is, therefore, such as to exaggerate their apparent amenorrhoea rate in the ratio of 28.3 over 25.4. The effect of age can, therefore, be eliminated by multiplying the observed rate—i.e. 37.0 by 25.4 over 28.3, giving a corrected rate of 33.2. In the same way, if age differences were eliminated, the mean incidence in the others would be 25.4 over 25.0 × 24.0 = 24.4.

TABLE XXVII.

	Age in years.					Mean incidence of amenorrhoea
	Under 20 (a)	20-21 (b)	22-24 (c)	25-27 (d)	Over 27 (e)	
(1) Percentage age distribution of only children	18.1	41.7	27.8	7.0	5.5	37.0
(2) Percentage age distribution of others	27.1	34.2	18.2	8.5	12.0	24.0
(3) Percentage age incidence of amenorrhoea, total sample	17.8	29.9	38.0	19.6	11.5	25.4

As age is known to have a marked effect on the liability to amenorrhoea at entry, the age composition of the 2 groups were compared. (Table XXVI.)

It is obvious that there is a difference in age composition of only children compared with the others. On the supposition that only children have the same age incidence of amenorrhoea as the total sample, the expected rate in only children with the above age distribution (Table XXVII) would be:

$$\frac{(a_i \times a_{iii}) + (b_i \times b_{iii}) + \dots + (e_i \times e_{iii})}{100} = 28.3$$

Assuming that the others have the same age incidence of amenorrhoea as the total

The following table compares these corrected rates:

TABLE XXVIII.

	Mean incidence of amenorrhoea corrected for age
Only children	33.2
Others	24.4
Difference	8.8
Standard error of difference ...	5.9
Ratio difference : S.E.	1.5

The difference is seen to be much reduced and no longer statistically significant.

3. *Relation of Amenorrhoea to Rank.*

The following table shows the incidence of amenorrhoea at entry by rank:

TABLE XXIX.

				Percentage at entry amenorrhoea	No. of Women
Officers	...	...	...	2.4	42
Cadets	...	...	...	21.9	35
Other ranks	...	...	...	27.9	406

There is no significance in the difference between rate in cadets and other ranks, the difference of 7.0 per cent. being less than its standard error of 7.3 per cent.

However, there is a marked difference between incidence in officers and the rest. The difference is 25 percent, which is nearly 8 times its standard error (3.3) and highly significant. Again the age distribution must be considered in each group. The expected rate in officers, with the age distribution given, assuming the same age incidence as of the total sample, would be 21.6. Therefore, correcting for age would bring the rate in officers up to 2.7, which leaves the contrast with cadets and other ranks as great as before.

The comparative rarity of amenorrhoea at entry among officers is remarkable in view of the fact that no officer interviewed had received a direct commission; the majority had served in the ranks for at least 1 year. The marked discrepancy between officers and officer-cadets is also interesting. It is probably accounted for by an alteration in the criterion of officers selection during the war. Nearly all the officers interviewed had been commissioned for longer than 2 years, many of them had been to boarding school, university, or into jobs away from home. This was not found to be so amongst the cadets. It is likely that in the case of the officers the transition to a communal life involved less emotional

strain, thus accounting for the low incidence of amenorrhoea.

SUMMARY.

A study has been made of normal and abnormal menstrual function in the A.T.S. Auxiliaries, over 700 women from all branches of the Service being interviewed with regard to social and personal background and menstrual history. The following conclusions were reached:

A. *Dysmenorrhoea.*

(1) Nearly 50 per cent did not admit to having symptoms at menstruation. Only in 23 per cent was there any interference with normal routine.

(2) The incidence of dysmenorrhoea is highest in the early twenties, and falls off markedly over 27 years.

(3) A high standard of physique and general health was associated with freedom from symptoms, whilst anxiety resulting from nature of employment appeared to aggravate dysmenorrhoea.

(4) No striking difference was found between the incidence of dysmenorrhoea in officers and other ranks. Inconclusive results were also found when comparing intelligence grades.

(5) Only children were found to have a lower rate of dysmenorrhoea, this being statistically insignificant in those who had been in the Army over 3 months, but significant in those who had recently enlisted.

(6) An increase in dysmenorrhoea was found in those having a protracted period and profuse flow.

B. *Irregularity of Cycle.*

(1) 16 per cent gave a history of irregularity.

(2) Like dysmenorrhoea, irregularity is highest in the early twenties, falling off in subsequent age groups.

(3) There was found to be a highly significant excess in dysmenorrhoea amongst those with irregular cycles. ✓

C. Menstrual Disorders at Entry to the A.T.S.

(1) Over 25 per cent of auxiliaries gave a history of one or more missed periods at entry to the A.T.S. 11 per cent suffered some other disturbance.

(2) As with other disturbances studied, incidence of amenorrhoea was highest in the early twenties. Girls entering the A.T.S. in their teens, or over 24 years, have a significantly lower rate.

(3) There was a higher incidence of amenorrhoea at entry in only children, which, however, was not significant.

(4) The rate for amenorrhoea amongst officers was only about one-twelfth that

found in other ranks, although all officers interviewed had previously served in the ranks. It is suggested that this large difference can be accounted for by the fact that many officers had previously been away from home at boarding school, University, or in jobs, and therefore the transition to a communal life involved less emotional stress in their case.

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REFERENCE.

¹Report of London Association of the Medical Women's Federation. *Lancet* 1930, ii, 57.

Classification of the Human Pelvis, with a Preliminary Note on the Evolution of the Anthropoid or Ultra-dolichopellic Type of Pelvis.*

BY

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I. INTRODUCTORY NOTE.

MOST systems of classification of the pelvis are obstetrical, and have an aetiological basis. There appears to be no classification by an anatomist. Anatomy in itself, as Bolk¹ pointed out, has no creative power but is entrusted with the function of controlling, a control indeed which morphology cannot dispense with. Morphology is dependent on a consideration of function (physiology) in addition to anatomy—the latter observes, the former explains. The anatomist has pursued his line of thought concerning the pelvis into the more profound region of ontogeny to the exclusion of the simpler consideration of the influence of the bony pelvis on parturition. Therefore, classification of the pelvis has been left to the accoucheur. The latter has attempted quite reasonably to classify the girdle on a pathological basis, having as his first consideration the recognition of the types that cause dystocia. It has been more difficult to identify the morphological characters of the pelvis that are most favourable to labour, that is, to discover what is the ideal female pelvis.

* The contents of this paper follow closely Part III of a D.Sc. thesis (1945) presented by the author to the University of the Witwatersrand, and entitled "A Critical Analysis of the Bantu Pelvis, with special Reference to the Female."

II. VARIOUS CLASSIFICATIONS.

1. Van Deventer,² in the first classification of the female pelvis in 1716, recognized 3 types: too large, too small, and too flat. Ingenuous as this grouping may appear, the analytical perspicacity displayed has not been significantly surpassed during the last two-and-a-half centuries. It is unlikely that there will ever be a simple and satisfactory classification of the pelvis, and the types of a given system will be useful for special purposes only. Pelves will, therefore, have to be grouped according to a prescribed purpose so that the basis may be, for example, obstetrical or anthropological.

2. Obstetrical classifications have been concerned with peculiarities, usually of a pathological nature, which give rise to dystocia: the morphology of the normal pelvis and its variations has been disregarded, except for a recognition of the small pelvis with average proportions (justo-minor or generally contracted pelvis). Thus Litzmann's,³ Kerr's,⁴ Williams's⁵ and Zangemeister's⁶ classifications vary only slightly, and are based on deformities due to (a) faulty development, (b) disease of the pelvic bones, (c) disease of the vertebral column and (d) disease of the lower extremities. These classifications are of little interest to the anatomist.

3. It was not until 1933 that a more satis-

factory classification on morphological lines was reported by Caldwell *et al.*⁷ Following von Stein's⁸ scheme of grouping pelves into round, longitudinal-elliptical, and transversely-elliptical, these workers recognized 4 parent types: (1) the gynaecoid or average female type, (2) the android type with a strong male tendency, (3) the anthropoid type which is longitudinal-elliptical, and which resembles the brim shape of anthropoid apes and to a less extent that of all other mammals, and (4) the platypelloid or transversely-elliptical type. In addition to the parent types there are 6 groups with mixed characters, for example, gynaecoid with anthropoid tendency or android with gynaecoid tendency (see Table I).

Caldwell *et al.*^{7,9} drew attention to the moderate frequency (about 12 per cent) of

has received universal recognition. The classification is sufficiently complicated to be poorly understood by the majority of its would-be adherents, and its value has only rarely been discussed. In addition to the statement that a pelvis belongs to 1 of the 12 classes seen in Table I, it is necessary to ascertain: (1) whether the forepelvis is narrow, rounded, etcetera, and (2) whether the pubic arch is wide, moderate, or narrow. Such a classification is too cumbersome, having only the merit of describing a pelvis, whereas the rationale of classifying an object is to reduce description by placing the object in a previously defined category. Because the Caldwell and Moloy system is accepted to-day, 167 Bantu dry pelves have been classified accordingly (Table I), and reference will be made to the principles underlying the scheme.

TABLE I.
Bantu Pelves (Caldwell and Moloy Classification). American-white Figures in Parenthesis.

Classification	Female		100 male
	No. of pelves	Percentage incidence	
True anthropoid type	9 (25)	13.4 (11.6)	16
Anthropoid with gynaecoid tendency ...	8 (14)	11.9 (6.5)	2
Gynaecoid with anthropoid tendency ...	4 (10)	6.0 (4.6)	12
Gynaecoid with narrow forepelvis ...	8 (24)	11.9 (11.1)	7
True gynaecoid type	19 (85)	28.4 (39.5)	15
Gynaecoid with flat tendency	4 (7)	6.0 (3.3)	0
True flat (platypelloid) type	1 (2)	1.5 (0.9)	2
Android with anthropoid tendency	4 (8)	6.0 (3.7)	4
Android with gynaecoid tendency	1 (11)	1.5 (5.1)	0
True android type	6 (25)	9.0 (11.6)	39
Android with flat tendency	2 (4)	3.0 (1.8)	2
Asymmetrical forms	1 (4)	1.5 (1.8)	1

the anthropoid type pelvis and described its labour mechanism. It is actually their great contribution to labour mechanisms which were studied radiographically in parturients,^{10,11} that has made this team of workers celebrated. This fame has unfortunately spread to their classification which

To avoid a lengthy exposition of the Caldwell and Moloy classification, it is suggested that the reader who is unacquainted with the system should refer to the authors' diagrams in their 1934 article.⁹ It is in this paper also that their ideas concerning the evolution of the pelvis are set out (pages

3, 6 and 7). The classification is based entirely on the nature of the pelvic brim, and more particularly on that part of it lying posterior to the widest transverse diameter of the brim, this segment being only a little different from Derry's posterior segment of the pelvic chilotic line¹² and Straus¹³ lower iliac height. In the anthropoid type of pelvis the distance of the transverse diameter from the sacrum is great, in the gynaecoid type intermediate in length, and in the android type the diameter lies close to the sacrum. The anterior half of the brim is also characteristic for the different types, and may give rise to mixed types. This scheme of grouping is followed fairly faithfully by Turner's brim index,¹⁴ making the types mentioned respectively dolicho-, mesati-, and platypellic. There is indeed small merit in applying a new terminology to these pelvic inlets.

Quite apart from the above morphological types, and excluded from the Caldwell and Moloy classification, there occur pathological types in regions where rickets is common, and which may range from antero-posterior flattening to the complete distortion found in osteomalacia.

Comparatively rare pathological and developmental anomalies may cause asymmetry due to faulty posture (disease of spine or lower limbs), or the contraction seen in the Naegele and Robert pelvis in which there is faulty development of sacral alae.

III. CALDWELL AND MOLOY CLASSIFICATION OF 167 DRY BANTU Pelves OF BOTH SEXES.

The classification in Table I of Bantu pelvises is based on the standard laid down by Caldwell *et al.*^{7,9} whose paper⁹ presented a classification of 215 American-white female pelvises, the figures relevant to which are here given in brackets after the Bantu figures.

It has been observed that the male pelvis exhibited several of the Caldwell and Moloy types, and an attempt was made to classify the male series according to the scheme for the female. It was surprising to find examples of nearly all the types, and even a male pelvic type which was hardly distinguishable from the essentially female gynaecoid type. In Table I male figures are seen opposite gynaecoid and android divisions: this analysis is recorded for the purpose of comparison, for whilst similarity to these female types does exist in the male, it is not intended to extend the connotation of gynaecoid and android to male pelvic types.

With a few exceptions, the table shows a fairly close correspondence between the 3 sets of figures. The Bantu sex differences *qua* incidence are seen (1) in the android parent type where the difference in favour of the male is 6.6 times its standard error; (2) in the gynaecoid parent type with a difference in favour of the female of 2.33 times its standard error. The higher incidence of true anthropoid types in the male has no statistical significance. Thus in the male series the highest incidence was in the android group, and in the female a high incidence of the same order was found in the gynaecoid group. The European female figures correspond in this respect with the Bantu. Apart from these 2 fundamental sex types, there is an appreciable correspondence between the females of the two races on one hand and the male Bantu on the other.

The true anthropoid type occurs in much the same proportion in both the Bantu and the American-white series. But if this group is taken together with the pelvises showing anthropoid tendencies, the Bantu female incidence is 37 per cent (34 per cent for the male), and the white 26 per cent. The difference for the female is 1.5 times its standard error; and for male and female

Bantu combined the difference from the white material is 2.0 times its standard error: significance for this difference has not been established by radiographic studies of 150 Bantu women.

The true gynaecoid type—the nearest approach to what is considered to be the ideal female pelvis—occurs in 28 per cent only of female Bantu pelvises as compared with 40 per cent of whites. This might be regarded as possibly significant, were it not for the fact that the gynaecoid type with corresponding tendencies (e.g. anthropoid, flat or narrow forepelvis) occurs with much the same frequency in both female series.

While it was surprising that in the female the true android type actually had a lower incidence (9.12 per cent) in the Bantu than in the white, the difference found is not significant. If all pelvises exhibiting android tendencies are grouped together, the Bantu female percentage is found to be 20 as compared with 22 in the American series.

The female types with flat tendency occurring both in the gynaecoid and in the android type show in each case nearly twice the percentage in the Bantu series as in the American. The gynaecoid figure at 6.0 per cent and the android at 3.0 per cent are so low as to lack significance. If this tendency were established in a larger series, it might be suggested that the underlying cause is associated with some factor such as rickets which is so prominent during Bantu childhood.

The purely asymmetrical forms shown could not readily be subclassified. Where asymmetry occurred in pelvises of other types, an alternative diagnosis was made.

IV. EVOLUTION OF THE HUMAN PELVIS: CRITICISM OF CALDWELL AND MOLOY'S VIEW.

Caldwell *et al.*⁹ have ventured beyond their classification in an attempt to explain the origin of the parent types. In this paper

their ideas are illustrated diagrammatically, and in the printed paragraph beneath the figure it will be seen that the authors refer to their belief in an evolutionary factor which is responsible for producing the typically platypellic human forms ranging orthogenetically from extreme dolichopelly to an ultra-human platypelloid human type. In the same paper they claim that this hypothesis is the most important contribution of their work.

The Caldwell and Moloy view is that orthogenesis begins in lower mammals where the pelvic inlet is always longest in the anteroposterior axis (brim index over 100), and ends with platypelly found in in man (brim index under 100). The authors assert that the occurrence of anthropoid type pelvises (10 to 20 per cent) is due to an arrest of evolution.⁹ These assertions will now be examined.

If the recapitulation theory is being invoked for the argument concerning the arrest of evolution there is a danger that evolution, or this process of "arrest in evolution," might be by-passing the foetus in respect to the pelvis. If the Caldwell and Moloy hypothesis is to mean anything, the picture before one is a high incidence of primitive "anthropoid type" pelvises in the foetus and embryo; a more human (possibly flattish) pelvis later during ontogeny; and at the end of ontogeny some more highly developed pelvis which is well removed from the ape (or lower mammalian) pelvis morphologically. Our authors choose to believe that this last, fully evolved, pelvis is their platypelloid type, i.e. a pelvis with an average brim index below 80. This presumption is based on very poor evidence, for not only have Caldwell and Moloy⁹ reported an incidence of only 2 per cent for this type, but the Bantu incidence does not rise above this figure, nor does the English (Ince and Young,¹⁵ Kenny¹⁶). Moreover, Caldwell

and Moloy have made no reference to any personal experience with foetal pelves, nor has any reliable pelvic work been reported by any writer in English. Kappers' monograph¹⁷ is the only available study of this kind which can be considered authoritative.

An ontogenetic survey of the Bantu pelvic brim demonstrates the following facts.

1. Seventeen of 100 fetuses had an index over 100 (or 100 and over). 33 per cent were dolichopellic (index over 95).

2. In 39 children aged 1 to 15 years. 15.4 per cent have indices over 100 and are of well-marked anthropoid type. But 35.9 per cent (14 pelves) have an index of 95 or more.

3. (a) In 45 adolescent females aged 15 to 19 years, 13.3 per cent had indices of 100 or 100 and over, and 28.9 per cent were dolichopellic.

(b) Of 31 females aged 20 to 25 years, 19.3 per cent had indices of 100 or more, and by some chance 48.4 per cent were dolichopellic.

(c) For adult indices of 100 or over, there were 17 of 100 male dry pelves, 12 per cent of 67 female dry pelves, 17 of 100 female X-rayed subjects, and 20 per cent of another series of 25 X-rayed women. The dry pelves exhibited the Caldwell and Moloy anthropoid type in 13.4 per cent of females and 16 per cent of males, both figures being very close to those given above (12 and 17 respectively).

Concerning the foetal brims mentioned under (1) above, the index reached 110 on only 2 occasions, and the brims never resembled the pronounced "anthropoid type" seen in the adult: they certainly do not approach the relative proportions of the ape brim. These high-index foetal brims are, in fact, only round, or "more round" than the average brim.

The infant and child pelvis moves further

in the direction of "roundness" than the foetal with a percentage difference which is 2.23 times its standard error. Now for the first time do outspoken "anthropoid types" appear—but the outstanding observation concerning the infant brim is the trend from flatness to roundness.

The percentage difference of indices 100 or over between the 1 to 15 and 15 to 19 year age groups is 2.5 times its standard error, and is probably significant. It is seen, therefore, that from infancy to puberty or thereabouts pelves are significantly less flat than those in the foetus on the one hand and those in the adolescent on the other. The figures for this adolescent period show no significant difference from the total figures for the age period 15 to 25 years; nor do the figures for the 15 to 25-year period differ significantly from the corresponding figures for the adult skeletal material.

The difference in the incidence of dolichopellicity in the 15 to 19 and 20 to 25-year age groups is only 1.7 times its standard error, and is not significant. Similarly, the difference in the dolichopellic incidence between the foetal and the 20 to 25-year groups is only 1.5 times its standard error. Adult and foetal incidence of this character correspond closely, being respectively 34.5 and 33 per cent; and the adult dolichopellic incidence is equally similar to that of the 15 to 25-year age group.

In the adult there occurs, on the average, a flatter pelvis than in the child. The "anthropoid type" incidence is still equal to that in the foetus, though the "anthropoid" appearance reaches greater emphasis in the specimens so characterized. Something happens at pubertal age to arrest the development of round or ultra-dolichopellic brims, but the basis of this is not evolution. The cause may be some combination of factors concerned with sex hormones, the influence of nutrition on metabolism, and

physical forces based on weight-bearing and progression.

There is no question here, as Hooton¹⁴ mischievously puts it, of running with the Lamarckian hare and hunting with the Weismann hounds. The possibility under consideration is whether orthogenesis is being exhibited in the case of the pelvis, or on this matter Caldwell and Moloy peak of an arrest in evolution. A point is, herefore, reached at which it appears that many dolichopellic forms, slight and exaggerated, should occur; but coincident in time there emerges the sex factor, and the adolescent phase is associated with only occasional development of the sort of pelvic brim which is found throughout the mammalian class. In the anthropoids, on account of their greater facial angle, the foetal head is held in flexion during labour and thus requires adequate width further forward in the pelvis than is necessary in, say, ungulates.

It is a point of no mean importance that Kenny's¹⁶ paper has established finally the belief that the pithecoïd ("anthropoid") type pelvis in women is associated with a minimum of dystocia, complicated labour being much rarer than with the "gynaecoid" pelvis. If labour in mammals be considered, it is not unreasonable to conclude that difficult labour may jeopardise the continuation of the species. Hence only pelvises favourable to easy expulsion of the foetus would evolve. In the anthropoid apes greater and rounder heads have developed, and the problem becomes more acute. Observations in *homo sapiens* have demonstrated that the flatter the pelvis, the more difficult does parturition become. Antero-posterior shortening in morphological types is very rare, but common in diseases causing softening of bone. Evidence is accumulating¹⁶ that human types of superior physical status possess on the average round brims, while showing a high

incidence of "anthropoid" types. There is mathematical certainty in the fact that, with a given perimeter such as is represented by the brim, a circle encloses the greatest area: as the circumference becomes compressed and alters shape, so there is a loss of area.

So far, then, from supposing that evolution strives for platypelly, the evidence is in favour of dolichopelly being the highest and most efficient attainment. Bolk,^{1, 12, 20, 21} in his hypothesis on retardation and foetalisation, has shown that morphologically the apes have advanced much further than man along the road of evolution. His idea was that human anatomical features are all tainted with foetal characteristics; and what represents only a transitional stage in apes, has in man become the consummation of ontogeny. All human races have not made equal progress on the developmental road, and Bolk mentions such examples as the Mongolian physiognomy which is a foetalisation effect absent in white races, and the persistence of a metopic suture which is much more frequent in white than in black races. Bolk emphasizes the necessity for embryonic potentialities in human tissues such as epiphyses which continue to grow over a very long period: phylogenetic maturity could be reached only very late, while retardation during ontogeny is inhibiting this evolutionary progress all the time. This inhibition is often essential for man (*vide* the late obliteration of cranial sutures).

In the pelvis the same process with side effects occurs. During ontogeny (5th to 10th years), attempts at evolving the dolichopellic ancestral pelvis are seen. These attempts appear to be suppressed at puberty; but a certain number of girdles, nevertheless break the bonds of the foetalising influence and become "anthropoid." The majority, however, now resemble the

foetus more closely than they did during infancy.

Although the factors which, in groups such as those studied by Thoms,²² make possible a pelvic development beyond the foetal stage are unknown, the available evidence contradicts the Caldwell *et al.* belief that the ultra-dolichopellic pelvis represents an arrest in an evolutionary movement which has platypelly as its purpose. There is no evidence for this ill-conceived viewpoint; and it is submitted that in one sense the reverse is true, namely, that the ape pelvis has developed further than man's which is foetal in character, though the latter shows a tendency to reach towards more efficient dolichopelly. If the foetus exhibited many well-developed "anthropoid" forms, and if during adolescence these forms diminished in number and essential characters leaving only a few "evolutionary arrests," Caldwell and Moloy would have gained their point. Unfortunately, the facts are inconsistent with their thesis.

COMMENTARY.

The view of Caldwell *et al.*⁹ that the platypelloid pelvis is the end-point of evolution in man, while dolichopelly (resembling the apes) demonstrates an arrest in evolution, has been refuted. Although only Bantu data were used for this argument, it must be stated that the figures of other observers provide equal support. Thus Kappers¹⁷ had only 4 per cent of foetuses with brim index of over 100, and Turquet's series²³ of 70 infantile pelves showed a brim index of 100 or more in 28.5 per cent. Preservation of these juvenile specimens has the effect of raising the index, with the result that the childhood period of ontogeny has always been credited with a very high dolichopellic incidence. Evidence gained from fresh pelves, however, shows that this observa-

tion is sound, and the Bantu X-ray results support it strongly.

The view advanced here is that the evolutionary purpose in man is to produce the "anthropoid type" pelvis. In accordance with Bolk's hypothesis, the retardation of the factors leading to pelvic maturity is sufficiently effective to leave the stamp of foetalization on the majority of adult pelves: a minority only excel, become phylogenetically more highly evolved, and are more efficient as ultra-dolichopellic pelves. The latter have relatively larger inlets, presumably because ilium and pubis grow more, in order to provide the long inlet which would have possessed a smaller area had it been round because of the earlier cessation of growth.

To classify pelves until more is known about their evolution is futile. Further ontogenic studies must be directed to X-ray investigation of many pelves during puberty and adolescence in an attempt to determine the factors responsible for development or arrest of the fully evolved human pelvis. Some knowledge of other primate foetal pelves is also necessary (Bolk²⁴ in 1926 published a paper on the comparative anatomy of a gorilla and a chimpanzee foetus, but this study is not available in South Africa.) The brim index is a promising basis for classification, but it may be necessary to consider other features of which the most significant appears at present to be the pubic arch. Turner's index is, therefore, still the most important determination as a basis for classification. A further observation is found in the fact that a pelvis may be small, average, or large in size; and for parturition this character of absolute size is an essential feature. Pathological anomalies must be considered in a category which bears no relation whatever to morphology. When the ontogenetic investigation now in progress in the Department of Obstetrics has

been pursued further, and the relative capacity of dolichopellic girdles has been determined accurately, a scientific classification may be evolved.

RESULTS.

1. Mean values of ilium/pubes index.

50 adult female	100.92	
40 adult male	103.30	
90 combined adult	102.39	Adult
39 age 15-19 years	82.92	Adolescent
43 age 1-15 years	89.34	Child

(a) No significant difference was found between males and females of the Adult group, and for statistical purposes the combined group was used.

(b) The difference for the means of the Adolescent and Childhood groups was 6.42 ± 2.66 , the difference being 2.41 times the standard error and, therefore, probably significant.

(c) When compared with the Adult mean, both the Adolescent and Childhood means reveal a difference which is highly significant.

Adult and Adolescent—Difference = 19.47 ± 1.935
 $= 10.05 \times \text{st. error}$

Adult and Child —Difference = 13.05 ± 2.42
 $= 5.39 \times \text{st. error}$

2. Percentage incidence of indices 100 and over.

It was found that only 2 adolescent pelves had an index of 100 or over, and 9 childhood pelves. In the adult, 29 out of 40 (72.5 per cent) males had the index 100 or over and the corresponding figures for the female were 32 out of 50 (64 per cent). This difference is seen reflected in the mean values above, and signifies greater length of the pubic portion of the iliopectineal line before the age of 20 years, and greater length of the iliac portion in the adult.

Significance for these variations, in addition to the results under 1 a, b, c, was

found by considering the percentage of the 100 plus against the 100 minus incidence.

(a) No significance was found for the difference in the male and female Adult incidence.

(b) The percentage difference between the Adolescent and Child groups was 18.5 ± 7.45 , which is 2.48 times its standard error.

(c) The percentage differences between either the Adolescent or Child groups on the one hand and the Adult on the other are highly significant.

Adult and Adolescent—Difference = 63.2 ± 5.87
 $= 10.78 \times \text{st. error}$

Adult and Child —Difference = 44.7 ± 8.34
 $= 5.36 \times \text{st. error}$

CONCLUSION.

In the respective results under b and c of 1 and 2, a remarkably close correspondence is found. That is, when the differences between the figures for means are compared on the basis of the standard deviations, the same order of significance is found as when the percentages of indices over 100 and under 100 are compared. The close correspondence suggests that the adult tendency is not only to have a higher index than in individuals under 20, but in fact to be over 100 when the latter are characteristically under 100.

This would mean that up to the age of 20 the pubes is longer than the ilium on the iliopectineal line, and in the adult the ilium is the longer. There are two possibilities for this pronounced difference between the adult and the growing individual.

(1) There may be an unforeseen technical reason, for the adult pelves are all taken from skeletal material, the other groups being derived from radiographic series of living individuals. At present there is not available a series of unselected adult radiographs for the sake of comparison.

(2) If, as is indicated by the figures,

there is this pronounced difference between adult and growing pelvis, it must be accepted that by the time adult age is reached the iliac portion of the iliopectineal line has outgrown the pubic portion, for up to the age of 20 years the pubic portion preponderates.

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APPENDIX

An unexpected finding has emerged from a consideration in the Bantu of the index based on the respective lengths of ilium and pubes which contribute to the iliopectineal line. Both lengths were measured in a straight line from point to point, that is, as chords, not arcs, of a circle. The pubic length was measured from the symphysis to the antero-inferior edge of the Y-shaped cartilage on the iliopectineal line, and the iliac length from the antero-superior edge of the cartilage to the sacro-iliac joint at its junction with the iliopectineal line. This form of measurement was carried out on radiographs from 39 male and female children aged 1 to 15 years and 43 females aged 15 to 19 years. In the latter group the Y-shaped cartilage is rarely seen on the film, but a fairly accurate method of locating it was adopted. In the adult 50 female and 40 male dry pelvises were used for the measurement.

A Nutritional Survey among Pregnant Women

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THE "nutritional state of the nation" has been a matter of grave concern to the politician, to the scientist, and to the doctor, during the period of war and its aftermath. Feelings both of anxiety and of assurance have been expressed in numerous pronouncements and editorial comments of lay and medical press; but a final conclusion has not been—nor is likely to be—possible as to whether the British public suffered any serious impairment of health as a result of their restricted dietary during the years of the emergency. The Medical Research Council's Report¹ of its very comprehensive survey of haemoglobin levels left little room for pessimism. The levels found in the blood of all classes studied compared favourably with what figures were available of pre-war haemoglobin percentages; and a study of weights and haemoglobin levels of several thousand women in munition factories (Davies, Gunson, Matheson and Pike²) revealed few abnormalities. But against these and other scientific demonstrations of an absence of any departure from commonly accepted ranges of physiological normality, there is a widespread conviction that not only the frustrations and inhibitions of the last 6 years, but also a lack of still undiscovered or improperly understood dietary factors from the restricted and monotonous war diet, may be the root cause of the susceptibility to minor complaints, such as winter colds, often developing into something more serious, which is alleged to exist.

If nutritional deficiencies do, in fact, exist—or have existed during the worst of the war years—it might be expected to find them most pronounced among pregnant women, where the drain from the physiological economy of the mother is severe under ordinary conditions of proper nourishment and replacement, and may result in demonstrable deficiencies where the essential mineral elements and vitamins, and even the more ordinary non-accessory food factors such as proteins, may be in short supply. Hamilton and Wright³ concluded, from a study of haemoglobin levels and a comparison with other published figures, that women of the artisan class were more anaemic than before the war. Craig and Lewis⁴ found a wide variation in the vitamin C saturation of pregnant women, and concluded that it was definitely on the low side. Protein levels in the plasma have been studied by Dyson¹ as part of the Medical Research Council's survey, but demonstrable departures from the range of accepted normal values have been seen only in such severe cases of starvation as those described by Vaughan, Dent, and Pitt Rivers⁵ in the concentration camp at Belsen, and by Walter, Rossiter and Lehman⁶ among prisoners of war released from Japanese prison camps.

The present investigation was undertaken in 1943 to determine if any evidence of malnourishment could be detected amongst the women of the Hammersmith district attending the prenatal clinic of this

hospital during the course of their pregnancies. Besides the usual careful clinical examination, the subjects were investigated chemically for the ascorbic acid and haemoglobin contents of their blood, and for the alkaline phosphatase activity of their plasma. It is well known that this enzyme accumulates in the blood of cases suffering from generalized bone disease, such as Paget's and von Recklinghausen's, and in the deficiency diseases of rickets, cranio-tabes and osteomalacia. Indeed it seemed the most promising means of investigating the possibility of abnormality in calcium-phosphorus metabolism, arising either through lack of the minerals or of vitamin D. Estimations of calcium and phosphorus were not undertaken because there is too little evidence that abnormal figures would be encountered in any other than cases of very severe malnutrition, and these we did not expect to find. Estimations of the urinary output of vitamin B₁ were undertaken even though there seemed considerable doubt, in view of the high content of aneurin in the National loaf, as to whether any deficiency might be expected: the results were inconclusive and have been published elsewhere (Simmons and Wootton'). This communication, therefore, is concerned with reporting the findings in respect of haemoglobin, vitamin C, and plasma phosphatase in a group of women during the course of their pregnancies, and subsequently, during 1943 to 1945.

PROCEDURE.

At this clinic, women wishing to book for their confinement in hospital report on one of two afternoons in the week. One of the research team was present on each of these afternoons, and 4 women were selected to take part in the investigation. On any one afternoon the first 4 women were chosen, whose duration of pregnancy (judged on clinical grounds) fell within the required

limit. Only patients less than 24 weeks pregnant were accepted; the majority were less than 18 weeks pregnant.

This technique of selection was designed to effect random sampling of the population in question. It must be noted that this does not necessarily conform to the general population of the area. Since the patients are those who wished to have their babies in hospital, it is likely that the population is weighted in favour of primigravidae; and also there is probably a relatively high proportion of women who have had previous obstetric complications.

Two samples of blood were required for the biochemical estimations. About 10 ml. of venous blood were oxalated and used for the determination of plasma ascorbic acid and plasma alkaline phosphatase. These determinations were carried out within an hour of the collection. For haemoglobin estimation, 0.05 ml. of blood obtained by ear puncture.

In a certain number of the cases, urinary excretion of aneurin was investigated. These results have already been reported.

The first specimens were taken at the end of the routine examination, during the initial visit of the women to the hospital. At the same time, a special note was made on the patient's history sheet to assist in tracing the patient throughout the pregnancy.

The second specimens were obtained from the same women during another routine visit between the 32nd week and term, usually about the 36th week. The third specimens were taken while the patients were in hospital during the first 10 days of the puerperium.

Between 6 and 12 months after the birth of her baby, each woman was sent a letter, requesting an attendance at the hospital, when the final specimens were taken.

A completed case was, therefore, investigated on 4 separate occasions, but for

various reasons it was impossible to complete a number of the cases. A few of the selected women aborted, whilst others were evacuated to other hospitals to avoid the dangers of enemy air activity. Response to the letters was in some ways discouraging. Much of this work was done during the period of the flying-bomb attacks, and as a result, many women had changed their addresses and could not be traced. Thus, unavoidably, a number of the cases, which had had the first one or two investigations done, could not be followed up. It was decided to include these cases in the survey, thus utilizing all the available data. The number of cases included at each stage of pregnancy therefore varies, but this is not considered a disadvantage, and allowance for it is made in the analysis.

During their attendance at the clinic, a number of the patients were interviewed by the Almoner's staff. The family income from all sources was assessed as accurately as possible. This was divided by the number in the family, and an estimate made of the income per head, with the object of discovering the effect, if any, of income upon the nutritional state.

BIOCHEMICAL METHODS.

(1) *Haemoglobin*. The alkaline haematin method of Clegg and King⁸ was employed, all readings being made on the photoelectric colorimeter, against a standard prepared from crystalline haemin. The reasons for considering this method superior to the Haldane estimation are outlined in that paper.

(2) *Plasma ascorbic acid*. Method of Farmer and Abt⁹ depending on the titration of a deproteinised filtrate with 2:6-dichlorophenolindophenol. More modern methods are more specific but we prefer it for the reasons expressed by Fleming and Sandford.¹⁰

(3) *Plasma phosphatase*. Estimated as King and Armstrong units by the modified method of King *et al.*¹¹ Disodium phenyl phosphate is hydrolysed under controlled conditions, and the liberated phenol estimated by photoelectric colorimetry. The unit is the amount of enzyme capable of producing 1 mg. of free phenol under the standard conditions.

RESULTS.

For the sake of brevity, the groups of patients at the different stages of pregnancy have been labelled as follows:

0-24 weeks:	Group A.
32 weeks-term:	Group B.
Immediate puerperium:	Group C.
6-12 months postpartum:	Group D.

In the analysis of results the 1 per cent level has in all cases been taken as the criterion of significance.

Haemoglobin results. The frequency distributions, means and deviations are set out in Table I. In order to facilitate comparison with the results of other investigators, the equivalent percentage on the Haldane scale is inserted in parenthesis, using the conversion factor evaluated by King, Gilchrist and Matheson.¹²

The mean haemoglobin falls from 12.3 g. (82.8 per cent) in early pregnancy to 11.6 g. (78.6 per cent) in late pregnancy. In the puerperium, the mean haemoglobin has almost regained the former value, and a still higher value of 13.1 g. (88.6) is reached in the postpartum subjects. Analysis of the variance demonstrates that these changes are highly significant.

	Within groups	Between groups	<i>z</i> .
Variance	89.32	1768.69	
Degrees of freedom	643	3	1.49

TABLE I.

Haemoglobin Frequency Distributions in the Four Groups.

Haemoglobin		Frequency			
g. Haemoglobin	Group A	Group B	Group C	Group D	
6.4-7.0	.	2 = 0.9%			
7.1-7.8	.	2 0.9			
7.9-8.6	4 = 1.5%	1 0.5	3 = 3.2%		
8.7-9.4	3 1.2	7 3.2	4 4.2		
9.5-10.1	17 6.5	17 7.8	5 5.3	1 = 1.4%	
10.2-10.9	22 8.4	34 15.5	6 6.4	3 4.1	
11.0-11.7	40 15.3	57 26.0	24 25.6	4 5.5	
11.8-12.5	68 26.0	48 21.9	18 19.1	12 16.4	
12.6-13.2	48 18.4	28 12.8	12 12.8	23 31.5	
13.3-14.0	39 14.9	14 6.4	10 10.6	16 21.9	
14.1-14.7	12 4.6	6 2.7	6 6.4	10 13.7	
14.8-15.6	5 1.9	2 0.9	5 5.3	3 4.1	
15.7-16.4	2 0.8	1 0.5		1 1.4	
16.5-17.2					
17.3-18.0	1 0.4		1 1.1		
Total No. of cases	261	219	94	73	
Mean	12.3	11.6	12.1	13.1	
Standard deviation	1.47	1.44	1.75	1.20	

In general these figures are similar to those found by previous investigators (Strauss and Castle,¹³ Widdowson,¹⁴ Hamilton and Wright³). The drop in haemoglobin during the advance of pregnancy is usually attributed to a "physiological hydraemia," but it has long been uncertain how much of the fall is in fact caused by a deficiency in dietary iron. The difference in haemoglobin between Group A and Group B is less than that found in most previous surveys,¹ but the resting, or non-pregnant haemoglobin level of 13.1 g. (88.6 per cent) is lower than the Price-Jones figure of 98 ± 10 per cent for normal women. Since it appears likely that the blood-volume returns to normal fairly quickly, this suggests that there is a certain amount of iron deficiency.

Plasma Ascorbic Acid. The changes in mean levels as given in Table II have been examined by analysis of variance.

	Within groups	Between groups	<i>z</i> .
Variance	0.0591	1.3578	1.56
Degrees of freedom	619	3	

These differences are significant.

Widely differing values are given by various workers for the mean plasma ascorbic acid during pregnancy. The discrepancies are probably due to two main factors; firstly, the differing methods of estimation used and secondly, the different plasma levels shown by communities with various ascorbic acid intakes. The work of

TABLE II.
Ascorbic Acid Frequency Distributions.

Ascorbic acid (mg./100 ml. plasma)	Frequency			
	Group A	Group B	Group C	Group D
0.10-0.20	4 = 1.5%			4 = 5.7%
0.21-0.30	13 5.1	15 = 7.2%		5 7.1
0.31-0.40	45 17.6	41 19.8	7 = 7.8%	5 7.1
0.41-0.50	44 17.2	37 17.8	26 28.9	6 8.6
0.51-0.60	48 18.7	32 15.5	24 26.7	5 7.1
0.61-0.70	31 12.1	21 10.3	11 12.2	13 18.6
0.71-0.80	20 7.8	27 13.0	11 12.2	9 12.8
0.81-0.90	20 7.8	15 7.2	5 5.6	6 8.6
0.91-1.00	12 4.7	13 6.3	4 4.4	6 8.6
1.01-1.10	9 3.5	3 1.5	1 1.1	5 7.1
1.11-1.20	7 2.7	3 1.5	1 1.1	2 2.9
1.21-1.30	3 1.2			2 2.9
1.31-1.40				1 1.4
1.41-1.50				2 2.9
1.51-1.60				1 1.4
1.61-1.70				1 1.4
1.71-1.80				1 1.4
1.81-1.90				
1.91-2.00				1 1.4
Total No. of cases	256	207	90	70
Mean	0.59	0.57	0.49	0.80
Standard deviation	0.24	0.22	0.17	0.36

Prunty and Vass¹⁵ shows that the plasma ascorbic acid may be taken as a reliable index of the nutritional state with regard to this vitamin. They found a close correlation between the plasma levels and the results of saturation tests, and concluded that 0.8 mg./100 ml. corresponds with a state of saturation, while normally the plasma level should not be less than 0.4 mg./100 ml.

Camara and Concepcion¹⁶ found the mean plasma ascorbic acid was 0.87 mg./100 ml. of plasma and could not detect any significant difference as pregnancy advanced. They suggest that the Filipinos whom they investigated, live on a diet particularly well provided with ascorbic

acid. A comparatively large fall was found by Snelling and Jackson,¹⁷ from 0.6 mg. during the first five months of pregnancy to 0.23 mg./100 ml. in the immediate puerperium. The latter figures show deficiency according to the standards of Prunty and Vass, but possibly some of the difference may be explained by the method of estimation used by Snelling and Jackson.

Other investigations (Teel *et al.*,¹⁸ Javert and Stander¹⁹) have provided results which lie between these extremes, and more in accord with the figures of the present investigation. The possibility that this fall is caused by minor degrees of deficiency cannot be discounted. It is supported by

the findings of Craig *et al*⁴ who noticed a wide variation in the results of saturation tests done on pregnant women.

Plasma phosphatase. During the tabulation of these results it was noticed that in addition to the values which might be con-

on the grounds of the other 96-99 per cent. These results have been placed in a separate category, and have not been taken into account during calculation of means and deviations. (See Table III.)

The rise during pregnancy, from 4.3

TABLE III.
Phosphatase Frequency Distributions.

Phosphatase		Frequency			
(Units/100 ml.)	Group A	Group B	Group C	Group D	
1.1-2.0	8 = 3.1%				
2.1-3.0	51 19.6				1 = 1.3%
3.1-4.0	66 25.4	1 = 0.5%	1 = 1.0%	4 5.3	
4.1-5.0	67 25.7	4 1.8	3 3.1	5 6.6	
5.1-6.0	39 14.9	10 4.5	5 5.2	12 15.8	
6.1-7.0	14 5.4	7 3.2	4 4.1	14 18.4	
7.1-8.0	7 2.7	21 9.6	11 11.3	13 17.1	
8.1-9.0	4 1.5	27 12.6	11 11.3	6 7.9	
9.1-10.0	1 0.4	26 11.8	16 16.5	6 7.9	
10.1-11.0		15 6.8	7 7.2	5 6.6	
11.1-12.0		27 12.6	11 11.3	7 9.2	
12.1-13.0		21 9.6	7 7.2		
13.1-14.0		18 8.2	5 5.2		
14.1-15.0		8 3.6	4 4.1	2 2.6	
15.1-16.0		11 5.0			
16.1-17.0		7 3.2	2 2.1		
17.1-18.0		3 1.4	3 3.1		
18.1-19.0		1 0.5	3 3.1		
19.1-20.0		4 1.8	1 1.0		
>10.0	4 = 1.5%				
>20.0		9 = 4.1%	3 = 3.1%	1 = 1.3%	
Total No. of cases	261	220	97	76	
Mean	4.3	10.5	10.4	7.6	
Standard deviation	2.0	3.0	3.5	2.5	

sidered normal in character, there existed a small residuum of 'abnormal' values. These comprised, in the different groups, about 1-4 per cent of the total number of estimations, and were in all cases grossly higher than the maximum to be expected

units in Group A (which is normal for non-pregnant women) to about 10 units in Groups B and C, is paralleled by the findings previously published (Cayla and Fabre,²⁰ Vermehren,²¹ Kerleau and Cayla²²). Exact comparisons are im-

possible, owing to the differing units of phosphatase activity. Several explanations have been advanced for this increase during pregnancy. Ramsay *et al.*²³ found significantly higher phosphatase values in "ill" patients than in "well", and suggest that there is evidence of unsatisfactory calcium and phosphorus metabolism among the "ill" patients.

Bodansky²⁴ thought that occasional high values might be due to increased parathyroid stimulation. High values were also found by Ebbs and Scott,²⁵ but they considered that these were mostly found in cases of twin pregnancy. This has not been substantiated in the present series. Five cases of twin pregnancy have been examined, their average phosphatase considered in Group B is 13.3 units.

It appears to us that both the above workers have, in fact, found examples of this class of abnormally high phosphatase levels. Follow-up of these cases already indicates a relationship with deficient calcium metabolism and infantile rickets. It is hoped to report these results more fully in a later paper.

Correlations. From among the large number of possible correlations, it was decided to select those which would help to answer two questions. Firstly, how far does the value of haemoglobin, plasma ascorbic acid or plasma phosphatase found in Group A enable a forecast to be made of the corresponding value in Group B? Also, does the possession of a low haemoglobin or plasma ascorbic acid, or of a high phosphatase, imply that the other biochemical indices will also be abnormal?

Correlations were calculated between the corresponding values in Groups A and B, and, in Group A, between the three estimations taken in pairs.

These results indicate that only in the case of haemoglobin, can the result in late pregnancy be forecast from early preg-

TABLE IV.

Correlation: Same patients in Group A and Group B.

Estimations	r	n	P
Haemoglobins	0.39	196	<0.01
Ascorbic acids	0.05	184	>0.1
Phosphatases	0.19	184	0.05>P>0.02

TABLE V.

Correlation: Group A patients—2 Estimations.

Estimations	r	n	P
Haemoglobin—Ascorbic acid	-0.13	247	>0.1
Ascorbic acid—Phosphatase	-0.11	248	>0.1
Phosphatase—Haemoglobin	0.07	248	>0.1

nancy. Also, no evidence exists of any state of general nutritional deficiency in the population under consideration.

Nutritional Status and Income-Level. The original grading of the income-levels by the Almoner's staff divided the patients into three grades. Weekly income per head: (1) more than £1; (2) 10 shillings to £1; (3) less than 10 shillings.

It was found that only a very few patients fell within the grade whose weekly income was less than 10 shillings per head. The latter 2 grades were therefore combined, so that in Grade R the weekly income per head was more than £1 and in Grade P the weekly income per head was less than £1. The mean levels for the two grades are set out in Table VI. The figure, in parenthesis indicates the number of cases from which the average is derived.

The mean levels are a sufficient indication that in this survey income level has apparently no bearing on the nutritional state. This is in agreement with the findings of Boycott,²⁶ though Reid and Mackintosh^{27, 28} showed that the incidence of anaemia could be correlated with the social status. It must be noted that in the present

TABLE VI.
Variation with Income Level.

	Group A	Group B	Group C	Group D
<i>Haemoglobin Mean</i>				
Grade R	12.3 (79)	11.8 (80)	12.2 (44)	13.1 (30)
Grade P	12.2 (108)	11.5 (103)	11.9 (48)	13.3 (28)
<i>Ascorbic Acid Mean</i>				
Grade R	0.52 (83)	0.59 (77)	0.53 (44)	0.78 (29)
Grade P	0.62 (101)	0.55 (95)	0.47 (45)	0.73 (30)
<i>Phosphatase Mean</i>				
Grade R	4.1 (82)	11.0 (76)	10.6 (45)	8.2 (30)
Grade P	4.4 (102)	11.1 (99)	10.1 (47)	7.4 (32)

survey the grading is dependent only on the statements of the patients, and may therefore be open to considerable error.

SUMMARY.

(1) Haemoglobin, plasma ascorbic acid and plasma alkaline phosphatase have been estimated on a random series of pregnant women, attending the antenatal department of this hospital. The mean levels and distributions at different stages of pregnancy are given.

(2) Evidence of nutritional deficiencies is discussed. There is no reason to suppose that any incidence occurs of a general nutritional deficiency.

(3) The results do not show that income level affects the nutritional state.

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Haemoglobin Values in Female Workers

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THERE is ample evidence available to prove that a low haemoglobin value is not uncommon in the female when the diet is poor in iron. In peacetime such an anaemia was prevalent in areas where economic distress and financial hardship prevailed. Anaemia and poverty went hand in hand. The work of Davidson in Aberdeen was pioneer in this field. In war, although the power to purchase may be at hand, the restrictions may be such as to diminish the intake of foods rich in iron and thereby produce a state of anaemia. It is for this reason that we investigated 2,000 females at an ordnance factory in the Midlands towards the end of last year (1942). The factory was selected for its proximity to London. Half of the workers are drawn from the surrounding areas, but the ones resident in hostels are drawn from all over the country and, therefore, cannot be regarded as typical of any one area. In fact, the majority came from large industrial areas in the North and from Scotland.

We approached the problem with some interest, for we had the opportunity of examining 2 distinct groups. The one 1,000 were women living at home and were travellers to and from their homes to the factory; the other 1,000 were residents at a hostel near the factory, freed from the difficulties of travelling and of domestic responsibility. In the former group, their food was their own affair; the latter group were fed

and housed, and their intake of food was known.

We were seeking information on many points. Are the women to-day showing a greater degree of anaemia than in peacetime? Are they receiving sufficient iron in their food to meet their demands? Are those who have to return to their homes less well off than those who are fed in hostels? Do those in hostels receive sufficient iron-containing foods to retain a good haemoglobin value?

There was no selection, and all the 2,000 were volunteers. Indeed, it can be said that all who were approached (while at work) volunteered with readiness, and it is meet and proper that this willingness to co-operate is recorded and acknowledged.

HAEMOGLOBIN DETERMINATION.

While the estimation of haemoglobin is a relatively simple procedure and one which has been performed in every hospital and laboratory for half a century, there is still a good deal of disagreement in medical circles regarding the methods employed and the interpretation of results. This unsatisfactory position has been recognized by the Medical Research Council in a recent attempt to procure uniformity by the advocacy of the Haldane method, with tube and pipette standardized by the National Physical Laboratory. The Haldane method

necessitates coal gas, and, unfortunately, our work was prosecuted in factory areas where coal gas could not be laid on. We therefore adopted King's method¹ of the alkaline haematin, and recorded our results in grammes. There is much to commend this way of recording haemoglobin values.

Osgood, Haskins and Trotman,² in 1932, concluded that the average haemoglobin value for women was 13.9 g. with a 90 per cent range of 12 to 15.5 g. It has long been accepted that the Haldane 100 per cent is equivalent to 13.8 g. Wintrobe³ gives 14.0 g. (± 2.0) as the normal figure for women and 16 g. for the male. Wintrobe also remarks on the "habit of expressing haemoglobin values in percentage as an unfortunate custom difficult to overcome". "A number of different values have been arbitrarily selected as the equivalent of 100 per cent. Thus the values as low as 13.8 g. and as high as 17.2 g. per 100 c.cm. of blood are still employed as the equivalent of 100 per cent" (Wintrobe).

Price Jones⁴ assessed the haemoglobin of 100 young women in 1931 and found the average to be 13.5 g., while Jenkins and Don,⁵ in 1933, recorded an average of 13.8 for 116 females.

The alkaline haematin method originated by Wu, used and recommended by Peters and van Slyke and by King in this country, was adopted by us all in our determinations. We used the photo-electric colorimeter and followed King's technique closely. This method measures the total pigment, is simple to use, and the standard for comparison is obtained from crystalline haemin with its known iron content. All samples were obtained from the lobe of the ear.

The hostel residents were within easy distance of the factory—a bus ride of five minutes. Each shift had separate quarters, so that those on the night shift were able to sleep undisturbed during the day. A large majority of the home residents had a

journey of an hour or more following their work, and many had some housework or shopping to do on arrival. Their sleep during the day was also less certain to remain undisturbed.

The determinations were conducted in the rest rooms adjoining the explosive shops, where the temperature remained constant. The vast majority were single women of 18 to 25 years of age. The duration of service varied, some having served 3 years, others only 3 months. Only a proportion of these 2,000 women were constantly exposed to T.N.T. in their work and, as we did not wish to inquire specifically into the haemoglobin values in relation to toxic substances, but rather to record the values in the female at work of a varied kind, we will not attempt to compare results in relation to actual occupation. On the whole, it can be said that the work is not hard or heavy, the shops are well spaced, there is no crowding and, at least during the day, there is abundant fresh air. The factory where our investigations were conducted is situated in the heart of the country, the women appear happy at their work, and there is relative security and reasonably good wages. The hours are also good. The morning shift is 48 hours a week, the afternoon 42 hours a week and the night 54 hours a week, giving an average of 48 hours.

Results are divisible into two main groups, those resident at home and those resident in hostel.

The first chart shows the haemoglobin values in 651 single females who reside at home, 498 of whom are under 25 years of age. It is seen that 267 (41 per cent) show a haemoglobin of 14.1 g. or more, and that 460 (70 per cent) show a haemoglobin of 13.1 g. or more. Seventy-seven recorded 12 g. or less, a percentage of 11.9, while 38 showed values of 11 g. or less, a percentage of 5.8. In other words, if we are to regard

a value below 12 g. as abnormal, some 10 per cent of these single women show this state, while about 5 per cent show figures below 11 g. and are definitely anaemic.

Of these 2,000 females 788, or 39.4 per cent, show haemoglobin values of over 14 g., while 1,385, or 69.2 per cent, show values of over 13 g.; 1,771, or 88.5 per cent,

SINGLE WOMEN RESIDENT AT HOME.

Grammes of haemoglobin	Years						Total
	18-20	21-25	26-30	31-40	41-50	51 and over	
Up to 8.0		2					2
8.1- 9.0	1	7	1		1		10
9.1-10.0	4	8	2	1			15
10.1-11.0	6	2	1	2			11
11.1-12.0	12	20	7				39
12.1-13.0	37	46	13	14	4		114
13.1-14.0	55	99	23	14	2		193
14.1-15.0	63	95	26	20	3		209
15.1-16.0	14	22	5	9	1	2	52
16.1 and over	1	4			1		6
	193	305	78	60	12	3	651

The married women resident at home numbered 349, and it is seen from the figures that they differ from the unmarried in that the percentage showing values above 13.1 g. is appreciably less—64 per cent (226). Fifty-six, or 16 per cent, record figures of 12 g. or less; and 36, or 10.3 per cent, values of 11 g. or less.

show values above 12 g., while 229, or 11.5 per cent record figures of 12 g. or less. Below 11 g. or less are 114, or 5.7 per cent.

The hostel residents were in the vast majority unmarried: 943 single and 57 married. Of the single, more than two-thirds were under 25 years of age, and only 120 were over 30 years of age. As can be

MARRIED WOMEN RESIDENT AT HOME.

Grammes of haemoglobin	Years				Total
	Up to 30	31-40	41-50	50 and over	
Up to 8.0		2			2
8.1- 9.0	3	1	3		7
9.1-10.0	6	1	7		14
10.1-11.0	4	4	5		13
11.1-12.0	10	5	5		20
12.1-13.0	35	25	11	1	67
13.1-14.0	39	27	14	2	82
14.1-15.0	39	24	18	8	89
15.1-16.0	17	12	14	4	47
16.1 and over	2	3	2	1	8
	150	104	79	16	349

GLOBIN VALUES IN FEMALE WORKERS

SINGLE WOMEN RESIDENT IN HOSTEL.

Grammes of haemoglobin	Years					Total
	18-20	21-25	26-30	31-40	41-50	
Up to 8.0		4	2	1		7
8.1- 9.0		3	3	3		9
9.1-10.0	2	6	1			9
10.1-11.0	4	6	1	2		13
11.1-12.0	7	27	10	9		53
12.1-13.0	37	104	30	27		198
13.1-14.0	49	157	67	27	3	303
14.1-15.0	39	148	44	25	7	263
15.1-16.0	12	41	11	11	4	79
16.1 and over	2	3	3	1		9
	152	499	172	106	14	943

MARRIED WOMEN RESIDENT IN HOSTEL.

Grammes of haemoglobin	Years				Total
	Up to 30	31-40	41-50	51 and over	
Up to 8.0					
8.1- 9.0					
9.1-10.0					
10.1-11.0	1		1		2
11.1-12.0	1	2			3
12.1-13.0	1	1	3	2	7
13.1-14.0	9	3	5	2	19
14.1-15.0	10	5	3		18
15.1-16.0	1	1	2	2	6
16.1 and over					
	23	12	15	7	57

een from the figures of the unmarried, out of a total of 943, 351 (37 per cent) showed a haemoglobin of 14.1 or more, and 654 (69 per cent) a haemoglobin of 13.1 or more. Ninety-one, or 9.6 per cent, recorded values of 12 g. or less, and 38, or 4 per cent, below 11 g.

The married residents in hostel are a small group of 57. This group is too small for analysis, but will be added to the larger group of married resident at home.

The two groups, 1,000 each, show little difference, although there is possibly a better picture in the hostel group. In both we can state that the haemoglobin values

are relatively good. The combined figures are shown in the following table:

Grammes of haemoglobin	Home	Hostel	Total
Up to 8.0	4	7	11
8.1- 9.0	17	9	26
9.1-10.0	29	9	38
10.1-11.0	24	15	39
11.1-12.0	59	56	115
12.1-13.0	181	205	386
13.1-14.0	275	322	597
14.1-15.0	298	281	579
15.1-16.0	99	85	184
16.1 and over	14	11	25
	1000	1000	2000

Of these 2,000 females 788, or 39.4 per cent, show haemoglobin values of over 14 g., while 1,385, or 69.2 per cent, show values of over 13 g.; 1,771, or 88.5 per cent, show values above 12 g.; while 229, or 11.5 per cent, record figures of 12 g. or less. Below 11 g. or less are 114, or 5.7 per cent.

When the additional work many of these women do in bringing up a family, travelling long distances to work and attending to their manifold duties, is realized it is pleasing to record such relatively low incidence of anaemia in married women at this stage of the war.

	Total Home		Total Hostel		Total	
	1000	per cent	1000	per cent	2000	per cent
Over 14 g.	411	41.0	377	37.7	788	39.4
Over 13 g.	686	68.6	699	69.9	1385	69.2
Over 12 g.	867	86.7	904	90.4	1771	88.5
12 g. or less	133	13.3	96	9.6	229	11.5
11 g. or less	74	7.4	40	4.0	114	5.7

The above table shows that the hostel figures, all in all, are superior to those of the home residents.

A similar finding is obtained when all the single women up to the age of 30 are listed into 2 groups of home and hostel, making a grand total of 1,399.

ANALYSIS OF THOSE SHOWING HAEMOGLOBIN VALUES BELOW 11 G.

Values below 11 g. are to be regarded as definitely abnormal. It is true that many women appear to carry on quite free of symptoms yet showing this degree of

Number	Single home		Single hostel		Total single	
	576	per cent	823	per cent	1399	per cent
Over 14 g.	230	40.0	303	36.8	533	38.0
Over 13 g.	407	70.0	576	70.0	983	70.0
Over 12 g.	503	87.0	747	91.0	1250	89.0
12 g. or less	73	13.0	76	9.0	149	11.0
11 g. or less	34	6.0	32	3.6	66	4.7

Here again the hostel figures are somewhat superior to the home resident figures.

The married women numbered 406, most of whom lived at home, undoubtedly contributing their share in domestic duties. The figures of their haemoglobin values are, as we should expect, somewhat less good than those of the single women but, even so, only 8 per cent of these show haemoglobin values which are decidedly low.

	406	per cent
Over 14 g.	170	42.0
Over 13 g.	271	66.0
Over 12 g.	345	85.0
12 g. or less	61	15.0
11 g. or less	38	8.0

anaemia, and it often surprises the clinician how relatively well many seem to fare and how free they are of symptoms of ill-health. On the other hand, we all well know the immediate benefit that is realized when such a state of anaemia is corrected.

Of our series of 2,000 women, 114 showed haemoglobin values of 11 g. or below. We can reasonably assume that the administration of iron would raise these values and in all probability increase their sense of well-being. It is to be admitted that these 114 people are working in a factory where toxic risks are run and where there is a full-time and adequate medical service: 114 in 2,000 means over 1,000 in 20,000 and, in itself, is sufficient reason for greater attention to be

paid to the determination of haemoglobin in people who are to undergo toxic hazards if we are to do our medical utmost to see that only fit persons are so exposed. The 114 were distributed as follows:

	Home	Hostel	Total
Single	38	38	76
Married	36	2	38
	74	40	114

Although the number is fortunately small, it is seen that there is a higher proportion of married women showing this grade of anaemia. Among the married a total of 406 (9.3 per cent) show this grade of anaemia; while of the total single, 1,594, the percentage is 4.7. It is also seen that there are more among those resident at home than among those at the hostel.

The Single Resident at Home.

This group includes 38 women. Menorrhagia was present in 3. Past recent infection had occurred in 6. In the remainder there was no factor in the history, past or present, we could connect with the existing anaemia. The majority had been in the factory service for a good time, 31 having served for a year or more.

3 months	6 months	9 months	1 year
4	2	1	6
1½ years	2 years	2½ years	3 years
7	7	5	6

Fourteen had been away sick for various reasons, but the remainder, 24 in number, in spite of their low haemoglobin values, remained at their work. As many as 23 spent two or more hours of their day travelling to and from their work. Although meals are provided in the factory canteen, only a

minority of the workers partake of a hot dinner of meat and vegetables. It is interesting to note that among these 38 anaemic women only 4 partook of these meals occasionally and none regularly.

The Married Woman Resident at Home.

This group includes 36 women.

	Total number of children
Up to 30 years of age	13
31 to 40 years of age	8
41 and over	15
	36

The number of children increases in the 3 groups. The 15 women over 40 years of age were mothers of 57 children—a substantial number—and with children the domestic responsibilities must also increase. In the first group, 4 enjoyed freedom from or only light responsibilities, while in the other 2 groups all confessed to heavy domestic duties. One of these latter women did remark that she was, however, relieved of her weekly washing!

Menorrhagia was a symptom complained of by 5, and 2 admitted to a postpartum haemorrhage from which date their anaemia persisted. History of recent infection was found in 8. Twenty gave no history of previous ill-health and, in spite of their anaemia, had had no leave of absence. Thirty-two had served a year or more, and 13 had served 2 to 3 years. Travelling appears to be a factor of some significance, for 25 spent 2 hours or more out of their day (or night) travelling to and from the factory. Only 1 admitted to partaking of the canteen meal regularly and 11 occasionally.

Behind these figures there is a fortitude which is worthy of respect and admiration. These are 2 examples :

A woman of 34 and the mother of 5 children, with heavy domestic duties, has worked in the factory for $2\frac{1}{2}$ years. $1\frac{1}{2}$ hours of her day are occupied in travelling. In spite of showing a haemoglobin of only 7 g. she has taken no sick leave for the $2\frac{1}{2}$ years, although she admits to taking 1 in 14 days to attend to her household duties.

Another, a woman of 41 and the mother of 6 children, suffering from menorrhagia since her last childbirth, and with heavy duties at home and a record of 2 years' service, 2 hours of her day occupied in travelling, shows a haemoglobin of 9 g. yet she has taken no sick leave.

The Single Women Resident in Hostel.

With good food and healthy surroundings, the incidence of anaemia should be less in a series of young women living in a hostel than in a similar series living at home with its attendant present-day difficulties. But, even in the hostel series of 1,000, there are 40 women who show a haemoglobin of 11 g. or less and who must, therefore, be regarded as anaemic. Of these 40, 38 are single.

One only complained of menorrhagia and 7 gave a history of recent infection. The others did not give any history which could in any way account for their low haemoglobin. Twenty-three had remained at their work without sick leave. Their period of service may explain, in part, the occurrence of anaemia in this hostel group, for out of the 38 only 10 had lived in the hostel for more than 6 months, while 28 were relatively newcomers. If we are to assume that the food of the hostel can be a potent influence in maintaining a good haemoglobin, we must admit that the shortness of the period during which these young women have lived in the hostel may be an explanation for their low values. It is certainly true

that the similar series of 38 resident at home showed an opposite state, for 31 out of the 38 had served for a year or more in the factory. It will be well worth while repeating these blood examinations in a year's time.

From a study of these 14 anaemic women it is seen that the group of married women living at home shows the highest incidence—36 out of a total of 349—a percentage of 10.3. Indeed, it is not surprising when we learn how full their day must be, with the travelling, the household duties, the children (57 among 15 mothers in 1 group), all in addition to their work in the factory. It is surprising how many remain at their task in spite of these extra duties and anaemia. Their high sense of duty in the face of this handicap is not unworthy of recognition.

Menorrhagia was complained of by 9, a symptom which might be in varying measure responsible for the anaemia. Recent infection might also be related to the anaemia, and there are records of 21 out of the 114 having suffered such an infection. In the remainder, there was no factor which could readily explain the anaemia.

Inquiry disclosed that this group of women use the factory canteen as little as the rest of the workers for, out of the 74 resident at home, only 15 admitted to the occasional use of the canteen and only 1 regularly. This is a pity, for their need is good food.

The difference in the incidence of anaemia between those resident at home and those in hostel is not striking. Of the 851 single women at home, 38, or 5.8 per cent, showed an anaemia, while out of the 943 resident in hostel, 38, or 4 per cent, showed this degree of anaemia. This lack of striking difference may be accounted for by our observation that only 10 of the hostel group of 38 had resided there for 6 months. In other words, the hostel figures a year hence may show a better state than we record to-day.

While the incidence of anaemia is not high, this figure of 5.7 per cent in a total of 2,000 is found within a factory where exposure to toxic risks is a daily event. There is no evidence that a better or worse state of affairs exists in the other factories, but a greater and wider interest seems called for in the simple determination of haemoglobin as a routine measure in persons who appear pale. It can hardly be wise to allow women with haemoglobin values as low as 10 g. to continue work on T.N.T. and other poisons. It also appears that more elastic measures are needed in dealing with married women; those who are over 40 years of age and who have large families (and who are more readily rendered anaemic) should be dealt with on a different standing from those who are younger and whose responsibilities are so much less.

Mention has already been made of the confusion which exists in interpreting values obtained by various methods of haemoglobin determination. The Haldane, which has been the most popular and widely-used method in this country, needs correction from time to time, and no great confidence can be placed in past results obtained by such a method that is not checked by some of the other methods, such as the oxygen capacity or the iron content. With the help of Professor Earl J. King and his colleague, Mrs. Gilchrist, we compared the new Haldane (passed by the National Physical Laboratory) with the alkaline haematin method used by us. Several independent determinations were made on the same blood by a direct and an indirect method in addition to the determination of iron in the samples.

From the experiments, it is concluded that 100 per cent Haldane is equivalent to 14.8 g. of haemoglobin and not 13.8 g. as formerly believed. If this is established and accepted it makes comparison with previous results still more difficult. If, however, we

take the 100 per cent Haldane of to-day as equivalent to 14.8 g. then:

14 g.	=	94 per cent
13 g.	=	88 " "
12 g.	=	81 " "
11 g.	=	74 " "
10 g.	=	67 " "

Interpreting our results on this basis, and converting them into the new Haldane, our figures for these 2,000 women could be recorded as follows:

39.4 per cent,	haemoglobin of	94 per cent or over
69.2 " "	" "	90 " "
88.5 " "	" "	82 " "
11.5 " "	" "	under 82 per cent
5.7 " "	" "	" 75 "

It is doubtful whether we can compare our results with past values. Wills⁴ published a study of 544 women in 1942, and in this series the mean haemoglobin was recorded as 12.3 g. and in a sub-group of nurses and students living in the country (where the diet was reported as poor) a mean of 11.6 g. These figures are certainly low, but it appears they found that factory workers (a number of 159) showed a better state, as the mean haemoglobin was 13 g. Davidson⁷ reported that 25 per cent of a series of childless women showed haemoglobin values below 85 per cent, and that of women with children 48 per cent showed values less than 85 per cent haemoglobin; but in his more recent study Davidson⁸ finds that only 7 per cent of adult females show a haemoglobin below 80 per cent, and he remarks "if haemoglobin values of this magnitude are found after nearly 4 years of war . . . then there is reason to believe that average haemoglobin levels even higher than those proposed by Price Jones might obtain in days of peace." From this we conclude that Davidson's findings in war are superior to those found in peace in "distressed" areas.

Although it is not possible to make any accurate comparison with records obtained before the war, it can be stated that the findings here recorded are moderately satisfactory and, in spite of wartime restrictions, the incidence of anaemia appears no greater than in times of peace.

In keeping with all other series the married women (especially those with large families) show a higher incidence of anaemia.

The young women in hostels, on the whole, show the best figures, and this is significant when it is recalled that they were in the main drawn from large industrial areas where the economic conditions were not good, and many were included who had resided only a short space of time in the hostels.

The haemoglobin determinations on 2,000 women showed results which appear to be relatively good. Only some 5 per cent showed haemoglobin below 11 g., whilst almost 70 per cent are above 13 g. The young women fed and housed in hostels showed the best haemoglobin values.

The married women showed a less satisfactory state and anaemia was almost twice as frequent in this group.

Haemoglobin values of 11 g. or less were encountered in 114 out of 2,000 (5.7 per cent). That this occurs in workers who are daily exposed to toxic risks in factories where there is a full and adequate medical service emphasizes the need for more attention to the haemoglobin determination of the blood. This simple examination should become a routine on all persons who appear pale.

ACKNOWLEDGMENT.

We owe sincere gratitude to many who have helped in this undertaking. Air Vice Marshal Sir David Munro, K.C.B. (as Chief Medical Officer of the Ministry of Supply when the work was executed), Professor E. C. Dodds, F.R.S., and Professor Sir J. Drummond gave constant encouragement. Professor E. J. King readily placed all his resources at our disposal. To Dr. Attwater (the senior Medical Officer at the factory where the main investigations were carried out), and to all the medical officers, we wish to record our thanks. The Birmingham University kindly housed one of us while conducting some of the analyses, and we also wish to acknowledge the help of Professor R. H. Hopkins and Dr. Robert Gaddie.

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Calcium and Phosphorus Metabolism in Pregnancy

(A Survey Under War and Post-war Conditions)

Preliminary Communication

BY

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FOR many years a routine survey of metabolism, including mineral metabolism, of a large number of patients during pregnancy seemed to show that a positive balance of calcium throughout pregnancy influenced not only the well-being of the patient but the character of the labour and the postnatal welfare of mother and child. Experience, however, demonstrated the extreme difficulty of ensuring a positive calcium balance in a considerable minority of women. This is due to the complexity of factors governing the absorption and retention of minerals, in particular, calcium. In the literature^{1, 2, 3, 4} at least the following factors are mentioned:

- (1) Gastric acidity.
- (2) The potential acid-base value of the food.
- (3) The acid-base balance of the body as a whole.
- (4) The acidity of the urine.
- (5) The calcium:phosphorus ratio in the diet.
- (6) Ingestion and digestion of fat.
- (7) The motility of the intestinal tract.
- (8) Parathyroid function.
- (9) Thyroid function.
- (10) Ovarian, pituitary, and possibly other endocrine influences.
- (11) Vitamin D ingestion and synthesis.

It is also realised that general constitutional factors and reactions to favourable and unfavourable emotional stimuli exert an influence, which, as yet, is not susceptible of quantitative measurement.

SCOPE OF SURVEY.

To elucidate some of these factors, a comprehensive and long-term survey was planned in 1942, to include as many clinical and biochemical data as possible. The objects of such a survey were to find out:

1. How far working-class diets during pregnancy can be considered adequate in the main nutritional requirements apart from minerals.
2. Whether actual deficiencies, correlated to functional disturbances, arise during pregnancy on the average diet consumed by working-class mothers.
3. Whether supplementary feeding of calcium phosphate alone would correct any errors detected.
4. Whether Calciferol, in addition to calcium phosphate, showed better results.
5. The effects of Calciferol supplements without the addition of the calcium salt.
6. The effects of varying doses of Calciferol with or without the calcium supplement—to arrive at an "optimum" dosage.

Thanks to the facilities provided by Mr. O'Sullivan, Obstetric Surgeon to Out-Patients at the City of London Lying-in Hospital, the survey was started in April 1943. The biochemical part of the work will be completed in the summer of 1946, and the final postnatal details collected by the summer of 1947.

The survey, which will be described in detail elsewhere, covers full clinical data, antenatal, natal and postnatal, of 50 subjects selected for their co-operativeness and

intelligence at the Out-Patients' department. The biochemical survey comprises a 48-hour period of weighing and measuring food and drink, the collection of all urine and stools over the same period, and a complete fasting blood analysis on each occasion—the intake figures being calculated from McCance and Widdowson's Tables,⁵ the blood and excreta being analysed in the writer's laboratory.

The majority of the women are healthy primiparae, a few cases have been included whose general health seemed good but who had previously miscarried or had a still-birth. A small number are also being included who had previously given birth to 1 healthy child.

SCOPE OF PRESENT COMMUNICATION.

The 50 subjects have been divided into groups. The present communication deals with 2 groups:

(1) A control group, whose calcium figures are given in Section 1 of Table I, and who were encouraged not to alter their usually dietary habits. They were also encouraged to avail themselves of the daily pint of milk under the National Milk Scheme. They also "benefited" from the chalk added to bread—throughout the survey—7 ounces to 280 pounds of flour.

(2) A group of subjects, whose calcium figures are given in Section 2 of Table I, otherwise similar to the control group, but who were given a supplement of calcium phosphate in doses which worked out to the following amounts of calcium and phosphorus elements per 24 hours:

	Calcium	Phosphorus
3rd to 5th months ...	0.64 g.	0.282 g.
6th to 7th months ...	0.95 g.	0.423 g.
8th month to term ...	1.26 g.	0.564 g.

Table I. The calcium figures given in this table have been extracted from a com-

prehensive tabulation of all the biochemical figures arrived at during each 48-hour investigation, that is:

(a) Blood—glucose, uric acid, inorganic phosphorus, cholesterol, calcium, urea, Amino-N, protein, refraction, viscosity, erythrocyte sedimentation-rate and haematology;

(b) Intake—protein, fat carbohydrate and calories, as well as acid or base predominance of the diet, expressed in milliequivalents;

(c) Similar detailed phosphorus intake and output figures to the calcium figures in Table I;

(d) pH and titrateable urinary acidity of each specimen passed during the 48-hour period as well as creatinin, chlorine and indican in the urine;

(e) Faecal pH, et cetera.

DISCUSSION OF SECTION 1, TABLE I.

Cases Nos. 1-6 were studied throughout pregnancy; Nos. 1 (age 24), 2 (age 31), 4 (age 31), 5 (age 24), 6 (age 21), were primiparae, No. 3 (age 25), had a normal previous pregnancy. No. 1 took a small daily dose of cod liver oil. None of the others took any vitamin supplement which might influence calcium or phosphorus metabolism.

Cases Nos. 7-12 were subjects who could only be investigated during the early part of pregnancy—either because of a spontaneous miscarriage, as in Cases Nos. 7 (age 23) and 8 (age 29), or a rise in blood-pressure followed by acute pyelitis, as in Case No. 10 (age 29), or because they left London owing to bombing, as in Cases Nos. 9 (age 29), 11 (age 32), and 12 (age 28).

With regard to Cases Nos. 13-22, the figures which are given at the end of Section 1 represent the findings of their initial investigations before supplementary feeding with calcium phosphate was started.

TABLE I.
TABULATION OF CALCIUM INTAKE AND OUTPUT FIGURES.
(The figures represent the findings of a 48-hour balance period in terms of grammes of calcium element.)

Section I.

Date	Week of pregnancy	Case No.	Calcium intake				Calcium in blood	Calcium in urine	Calcium in faeces	Total calcium out	Calcium balance
			Milk	Cheese	Other foods	Total					
28. 2.1943	13	1	1.51	Nil	0.30	1.81	9.5	0.69	3.04	3.73	-1.92
10. 4.1943	19		1.32	Nil	0.28	1.60	10.4	0.54	2.60	3.14	-1.54
27. 5.1943	25		1.80	0.24	0.23	2.27	9.8	0.63	1.59	2.22	-0.05
12. 7.1943	31		1.15	Nil	0.30	1.45	9.3	0.73	3.84	4.57	-3.12
15. 3.1943	12	2	0.68	0.39	0.26	1.33	10.7	0.40	2.20	2.60	-1.28
28. 4.1943	19		2.10	0.37	0.27	2.74	10.5	0.84	3.64	4.48	-1.74
9. 6.1943	26		1.82	0.24	0.36	2.42	9.9	0.48	4.23	4.23	-1.81
20. 7.1943	32		1.42	0.74	0.35	2.51	9.9	0.39	3.10	3.49	-0.98
31. 8.1943	37	3	1.20	0.58	0.43	2.21	10.4	0.24	1.77	2.01	+0.20
28. 6.1943	7		0.74	Nil	0.45	1.19	10.7	0.67	1.58	2.25	-1.06
3. 8.1943	13		0.91	0.44	0.46	1.81	10.3	0.37	1.58	1.95	-0.14
15. 9.1943	19		0.84	0.67	0.55	2.06	10.8	0.51	1.87	2.38	-0.32
1. 11.1943	25	4	0.98	0.89	0.71	2.58	9.5	0.69	2.88	3.57	-0.99
13. 12.1943	31		1.22	0.45	0.61	2.28	10.2	0.77	3.03	3.80	-1.52
30. 1.1944	37		1.88	0.82	0.34	3.04	10.0	1.00	6.00	7.00	-3.96
20. 10.1943	12		1.13	0.54	0.27	1.94	11.6	0.91	1.90	2.81	-0.87
24. 11.1943	17	5	1.42	0.23	0.46	2.11	10.2	0.58	2.45	3.03	-0.92
4. 1.1944	23		2.05	Nil	0.38	2.43	9.9	0.37	5.05	5.50	-3.07
15. 2.1944	29		1.54	0.51	0.57	2.62	10.2	0.59	3.24	3.83	-1.21
13. 4.1944	36		1.44	Nil	0.29	1.73	10.0	0.36	2.18	2.54	-0.81
6. 3.1944	21	6	0.72	0.45	0.41	1.58	10.0	0.76	0.84	1.60	-0.02
27. 4.1944	27		0.47	Nil	0.69	1.16	10.0	0.81	0.99	1.80	-0.64
7. 6.1944	33		1.26	Nil	0.61	1.87	10.4	0.72	0.78	1.50	+0.37
10. 7.1944	38		0.54	0.22	0.45	1.21	9.7	0.32	2.44	2.76	-1.55
16. 5.1944	14	7	1.34	0.24	0.47	2.05	10.0	0.44	1.90	2.34	-0.29
30. 7.1944	21		1.52	Nil	0.50	2.02	9.2	0.48	2.10	2.58	-0.56
21. 9.1944	28		1.53	Nil	0.39	1.92	10.0	0.82	0.99	1.81	+0.11
25. 10.1943	9		1.97	0.16	0.39	2.52	10.7	0.61	2.42	3.03	-0.51
24. 4.1944	9	8	0.72	Nil	0.42	1.14	10.6	0.64	1.43	2.07	-0.93
19. 5.1944	12		0.94	0.57	0.36	1.87	10.5	0.74	1.74	2.48	-0.61

TABLE I.

Section I (continued)

Date	Week of pregnancy	Case No.	Calcium intake				Calcium in blood	Calcium in urine	Calcium in faeces	Total calcium out	Calcium balance
			Milk	Cheese	Other foods	Total					
4. 5.1943	20	10	1.60	Nil	0.41	2.01	10.7	1.22	0.94	2.16	-0.15
4.10.1944	9	11	0.58	Nil	0.74	1.32	10.9	0.77	0.69	1.46	-0.14
30. 9.1944	10	12	0.97	0.23	0.41	1.61	9.9	0.73	3.05	3.78	-2.17
18.11.1944	17		0.94	0.41	0.71	2.06	10.4	0.39	4.50	4.89	-2.83
3. 3.1943	9	13	0.86	0.52	0.42	1.80	10.5	0.34	2.45	2.79	-0.99
9. 4.1943	14		1.20	0.49	0.43	2.12	10.2	0.49	3.05	3.54	-1.42
15. 3.1943	11	14	1.08	Nil	0.31	1.39	10.8	0.39	1.24	1.63	-0.24
28. 5.1943	17		1.90	Nil	1.10	3.00	10.6	0.83	2.55	3.38	-0.38
20.10.1943	12	15	1.01	0.23	0.27	1.51	11.0	0.53	1.80	2.33	-0.82
3. 2.1944	15	16	0.96	0.45	0.40	1.81	11.4	0.99	2.71	3.70	-1.89
23. 9.1944	11	17	1.52	Nil	0.38	1.90	11.5	0.74	1.90	2.64	-0.74
9.12.1944	15	18	1.28	0.12	0.59	1.99	10.8	0.53	2.50	3.03	-1.04
8. 3.1943	16	19	1.56	0.12	0.19	1.87	10.3	0.37	2.80	3.17	-1.30
9. 4.1943	20		1.16	0.36	0.19	1.71	9.8	0.49	1.62	2.11	-0.40
15. 4.1943	10	20	1.63	0.61	0.44	2.68	10.3	0.71	2.12	2.83	-0.15
31. 5.1943	16		1.50	Nil	0.38	1.88	10.7	0.79	1.05	1.84	+0.04
17.10.1943	12	21	1.70	0.22	0.28	2.20	11.4	0.94	3.24	4.18	-1.98
22. 1.1944	21	22	0.96	Nil	0.25	1.21	10.2	0.63	1.14	1.77	-0.56

NOTE—The figures on each line represent the findings of a 48-hour balance period—figures in the text for a 24-hour period are arrived at by halving.

TABLE I.

Section 2

Date	Week of pregnancy	Case No.	Calcium intake				Calcium in blood	Calcium in urine	Calcium in faeces	Total calcium output	Calcium balance
			Milk	Cheese	Other foods	Sup.	Total				
18. 5.1943	20	13	2.02	Nil	0.50	1.26	3.78	0.78	5.40	6.18	-2.40
25. 6.1943	26		2.15	0.12	0.42	1.89	4.58	0.66	6.35	7.01	-2.43
22. 8.1943	35		1.80	0.61	0.26	2.52	5.19	0.43	4.32	4.75	+0.44
8. 6.1943	23	14	1.17	Nil	0.47	1.89	3.53	0.75	3.25	4.00	-0.47
20. 7.1943	29		1.46	Nil	0.55	2.52	4.53	0.91	3.18	4.09	-0.44
31. 8.1943	35		1.55	Nil	0.44	2.52	4.51	0.65	1.70	2.35	+2.18
23.11.1943	17	15	1.66	Nil	0.53	1.26	3.45	0.73	2.12	2.85	+0.60
9. 1.1944	23		1.45	0.37	0.50	1.89	4.21	0.42	7.65	8.07	-3.86
18. 2.1944	29		1.91	0.29	0.59	Nil	2.79	0.66	3.96	4.62	-1.83
6. 4.1944	36		1.81	Nil	0.96	2.52	5.29	0.26	1.58	1.84	+3.45
21. 3.1944	21	16	0.86	0.23	0.42	1.26	3.77	0.68	1.90	2.58	+1.19
10. 5.1944	28		1.50	0.11	0.36	1.26	3.23	0.96	6.50	7.46	-4.23
30. 6.1944	35		0.81	0.19	0.43	1.89	3.32	0.91	4.55	5.46	-2.14
4.11.1944	17	17	2.01	Nil	0.31	1.26	3.58	0.68	1.06	1.74	+1.84
14.12.1944	23		2.28	0.41	0.33	1.26	4.27	0.73	0.82	1.55	+2.72
26. 1.1945	29		1.75	Nil	0.37	1.89	4.01	1.03	0.61	1.64	+2.37
9. 3.1945	35		1.26	0.27	0.44	Nil	1.97	0.61	1.82	2.43	-0.46
27. 1.1945	21	18	2.21	0.41	0.51	1.45	4.58	0.68	3.55	4.23	+0.35
12. 3.1945	27		2.21	Nil	0.51	2.08	4.80	0.88	5.80	6.68	-1.88
23. 4.1945	33		2.41	0.27	0.61	2.08	5.37	0.96	5.90	6.86	-1.49
28. 5.1945	38		2.52	Nil	1.12	2.71	6.35	0.38	5.10	5.48	+0.87
19. 5.1943	26	19	1.32	0.06	0.55	1.89	3.82	0.50	5.39	5.89	-2.07
25. 6.1943	31		1.12	0.12	0.32	2.52	4.08	0.57	4.64	5.21	-1.13
3. 8.1943	37		1.32	0.11	0.22	2.52	4.17	0.32	2.12	2.44	+1.73
12. 7.1943	21	20	1.00	0.12	0.51	1.89	3.52	0.76	4.52	5.28	-1.76
18. 8.1943	28		2.30	0.48	0.33	1.89	5.00	1.09	2.96	4.05	+0.95
4.10.1943	36		1.58	0.22	0.35	2.52	4.67	0.63	3.90	4.53	+0.12
22.11.1943	17	21	1.80	0.23	0.32	1.26	3.61	0.94	3.34	4.28	-0.67
5. 1.1944	23		1.46	0.11	0.40	1.89	3.86	0.86	3.39	4.25	-0.39
16. 2.1944	29		1.58	0.23	0.49	1.89	4.19	0.94	4.50	5.44	-1.25
23. 3.1944	34		1.88	Nil	0.40	2.52	4.80	1.13	2.56	3.69	+1.11
26. 2.1944	27	22	1.94	Nil	0.43	1.26	3.63	1.20	1.16	2.36	+1.27
10. 4.1944	33		1.83	Nil	0.62	1.89	4.34	0.62	1.66	2.28	+2.06

DISCUSSION OF SECTION 2, TABLE I.

The figures given cover the investigations carried out in Cases Nos. 13-22 from about the 4th month of pregnancy to term on supplements of calcium phosphate in the doses specified above.

Cases Nos. 14 (age 31), 15 (age 23), 16 (age 26), 18 (age 26), 19 (age 24), 20 (age 34), and 22 (age 21) were primiparae. No. 13 (age 31) had been induced at the 32nd week of a previous pregnancy, in August 1941; because of pregnancy toxæmia, resulting in a small stillborn male foetus. No. 17 (age 30) and No. 21 (age 22) had both had 1 previous normal pregnancy, the former in 1935, and the latter in 1941.

Owing to a miscalculation in her supplies, Case No. 15 ran out of her supplement of calcium phosphate a short time before the

will be noted that there was a heavily negative calcium balance on this occasion.

Case No. 17 had considerable digestive disturbance towards the end of pregnancy and claimed that she could not take the supplement during her last investigation, carried out at the 35th week. In this case also there were negative balances of both calcium and phosphorus, even at this late stage of pregnancy.

DISCUSSION OF CALCIUM AND PHOSPHORUS REQUIREMENTS.

A large number of correlations have been worked out on the total number, 81, of 48-hour balance periods recorded in Table I. The number of negative and positive balances are shown in Tables II and III.

TABLE II.

Analysis of Calcium Balances in both Control and Calcium Phosphate Groups.

CALCIUM.

48 Control balances (from Table I, Section 1).					33 Balances from cases supplemented with calcium phosphate (from Table I, Section 2).				

Potential acid or base predominance of the food;

The calcium:phosphorus ratio of the ingesta;

Urinary acidity.

On the other hand, striking results were arrived at when the 81 balances in Table I were analysed in relation to calcium-intake levels. The figures, which speak for themselves, are given in Table IV.

As would be expected, no correlation

cedure such as a 24-hour urinary calcium analysis could be used as a short cut. As the average 24-hour calcium output for 57 negative calcium balances was 0.33 g. and 0.35 g. for 24 positive balances, it is clear that such a short-cut procedure cannot be relied on.

Robertson⁶ gives the calcium requirements of the body during pregnancy and lactation as about 2 g. per day, and stresses the curious fact—borne out by the present

TABLE IV.
Correlation between Calcium-Intake Levels and Calcium Balances.

Intake per 24 hours	No. of balances	Balance positive	Equilibrium	Balance negative	Percentage of negative balances
Below 1 g.	27	21*	1	25	93
Between 1.1-1.5 g.	20	2	1	17	86
„ 1.6-2.0 g.	12	4	—	8	67
„ 2.1-2.5 g.	15	10	—	5	33
„ 2.6-3.0 g.	3	2	—	1	33
Over 3 g.	1	1	—	—	0

* Balance not reliable—bowels were disturbed for several days before investigations.

could be found between the serum-calcium levels and negative or positive calcium balances. The average serum-calcium level correlating with the 56 negative balances was 10.3 mg. per cent and 10.4 mg. per cent for the 20 positive balances. Other observers^{7, 8} have also shown that no reliance can be placed on the small variations in the serum-calcium level for the purpose of determining whether calcium metabolism is normal or not in any given case.

The urinary calcium figures were similarly analysed in relation to positive and negative balances. This was done because the 24-hour urinary calcium figure in male adults and non-pregnant females can often be interpreted as an expression of overflow. It was hoped, therefore, that there might also be some correlation in this series, so that a relatively simple and quick pro-

cedure—*that there is no mechanism for conserving calcium in spite of abnormal demands made on the body.* The National Research Council, U.S.A. 1941 (Food and Nutrition Board), recommends an intake of 1.5 g. of calcium during the latter half of pregnancy and 2 g. during lactation. The figures given in Table I, Section 1, show that such high intake levels are rarely arrived at in ordinary out-patient practice, and those in Table I, Section 2, that intake levels even higher than those recommended by these authorities sometimes fail to ensure a positive balance.

Macy and her co-workers⁹ refer to the anxiety factor. It is noteworthy that all the observations recorded in Table I fall into the war period. It may well be that in the presence of powerful and prolonged anxiety, the “safety” levels of calcium intake, as indicated by the figures in Table

IV, may be somewhat higher than under more normal conditions. More light may be thrown on this point when the figures for the post-war part of the survey have been completed and analysed.

Table V shows a less positive correlation between different levels of phosphorus intake and phosphorus balances.

group of cases given heavy supplements of calcium phosphate. Cases who have been or are being given varying doses of Calci-ferol either alone or with a calcium phosphate supplement will be dealt with in later publications.

4. The figures are discussed and analysed. No particular correlation

TABLE V.

Correlation Between Phosphorus Intake Levels and Phosphorus Balances.

Intake per 24 hours	No. of balances	Balance positive	Equilibrium	Balance negative	Percentage of negative balances
Below 2 g.	2	1	1	—	0
Between 2.1-2.5 g.	13	1	1	11	84
„ 2.6-3.0 g.	11	4	4	3	36
„ 3.1-3.5 g.	15	11	—	4	27
„ 3.6-4.0 g.	17	7	2	8	46
„ 4.1-4.5 g.	12	7	2	3	40
„ 4.6-5.0 g.	5	3	—	2	40
Over 5 g.	4	3	1	—	0

The factors which govern phosphorus metabolism are even more numerous and complex than those which govern calcium metabolism. The phosphorus-balance figures on subjects fed on Calci-ferol may throw further light on this subject. These will be published at a later date.

SUMMARY.

1. The many factors known to influence calcium and phosphorus metabolism are enumerated.

2. A description is given of the general plan, scope and objective of a comprehensive survey of metabolism throughout pregnancy on 50 women. This survey covers the period of years during the war and will be completed 2 years after V.E. day and will include postnatal data.

3. The calcium intake and output figures are given in table form. These figures cover a group of control cases who were not given a supplement of calcium phosphate and a

between any of the other findings and negative or positive calcium or phosphorus balances can be established.

5. The only definite correlation found and stressed is between the levels of calcium intake and negative and positive calcium balances (Table IV). The figures which emerge from this table suggest that standards quoted by various authorities to represent optimum or "safety" levels of calcium intake during pregnancy, are too low.

6. The correlation between levels of phosphorus intake and phosphorus balance is found to be more difficult of interpretation.

7. Among 12 control cases with a large predominance of negative calcium balances 1 case had a stillbirth and there were 2 spontaneous miscarriages. The 10 cases fed on calcium phosphate supplements had uneventful pregnancies and normal labours. As all the cases reported on in this

preliminary communication were investigated during wartime, the factor of anxiety is mentioned. No conclusions can, however, be drawn until the figures for the post-war section of the survey have been completed and analysed.

CONCLUSIONS.

1. Deductions cannot as yet be drawn from the findings in this survey as to optimum phosphorus intake during pregnancy.

2. The average calcium intake of pregnant women not receiving supplements of a calcium salt, is inadequate to ensure a positive balance. The usual "safety" intake levels given are probably too low. The figures given in this preliminary communication would tend to show that an intake of not less than 2 g. of calcium element from the beginning of pregnancy to the end of the 7th month and 2.5 g. from the 8th month to term should be considered as the minimum "safety" levels.

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Residential Rest during the Antenatal Period

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DURING the war emergency antenatal hostels and maternity homes were started as a result of the transfer of expectant mothers from the more heavily bombed areas to the country. The homes were often large, converted houses with little of the hospital atmosphere about them, and the impression was gained that the mothers delivered in these homes had a shorter labour than those delivered in maternity units incorporated with hospitals. The mothers confined in the maternity home usually spent some time in the antenatal hostel before delivery, where they were looked after, followed a regular routine, and had no household cares. It was thought that this period of rest and relative freedom from worry might be a factor contributing towards shorter confinements. The following investigation was therefore planned to discover evidence in favour of or against this view.

MATERIAL AND METHODS.

The case histories and clinical findings in 571 maternity patients delivered between June 1944 and June 1945 were examined. These patients fell naturally into 2 groups according to their place of delivery, either in hospital or maternity home. The groups were alike in age distribution and economic status as judged by the Registrar-General's classification. With the rationing system in force, very few of the women had failed to take up the extra allowances and

vitamins given during pregnancy, so that the 2 groups had had a comparable diet throughout the antenatal period.

Dieckmann and others,¹ in dietary studies made during pregnancy, have shown that the addition of vitamins and minerals to the diet does not alter the length of labour as compared with a control group receiving no extras. Burke and Harding² have shown that the addition of protein to the diet, although it affects the birth weight and length of the infant, has no significant effect on the duration of labour. This has been confirmed by a committee appointed by the People's League of Health,³ which studied the diet of 5,000 expectant mothers with regard to its effect on maternal and infant mortality and morbidity. Schuitema,⁴ however, has shown that a salt-poor diet does affect the length of labour. He found that in 46 normal primiparae, on a diet containing less than 3 g. of salt in 24 hours, the average length of labour was 7.3 hours, as compared with a control group of 41 in which the average was 9.0 hours with much greater individual variation.

It is probably safe to assume that few, if any, of the hospital patients in the present series were on a salt-poor diet, owing to its unpalatability, while the group delivered in the maternity home was not on any dietary restriction while at the antenatal hostel.

In the present series of cases abnormalities attributable to pregnancy or otherwise occurred in 128 patients, either

during the antenatal period, during delivery and necessitating obstetrical interference, or during the postnatal period. In view of the variety of abnormality in these cases, and the fact that they preponderated at the hospital, they were all excluded from the series. The subsequent analysis deals only with the 443 completed normal and spontaneously delivered cases which were grouped as shown in Table I.

During this time they helped with the domestic work in rota, had 2 hours rest every afternoon, were up at 8 a.m. and in bed by 10 p.m.

RESULTS.

A comparison of the mean duration of labour in hours between the age groups in the two series is shown in Table II.

As was to be expected, the table shows

TABLE I.

Age groups (years)	Hospital cases		Maternity home cases	
	Primigravidae	Multiparae	Primigravidae	Multiparae
15-25	117	4	72	15
26-35	79	32	36	49
36+	10	15	2	12
Total	206	51	110	76

In all cases routine antenatal supervision was carried out, and in addition the diet, economic status, nature and duration of employment outside the home were ascertained. The hospital and maternity home where these patients were delivered used the same records for making observations during delivery, and the staff at the 2 places came from the same training school, so that the same methods were used during the confinements of the 2 groups. A patient was considered to be in labour when regular pains started, and the duration of labour was noted from this time to the birth of the baby.

In the hospital series, patients were admitted at the onset of labour. Up to this time they were either in employment or had domestic responsibilities. The cases delivered in the maternity home had a period of rest in an antenatal hostel before admission when labour commenced. All the women in this group were evacuated from London, and the length of stay in the hostel before delivery varied from 0-74 days, the average period being 26 days:

that primigravidae have a longer labour than multiparae. In the hospital series the difference at all ages is 6.7 hours, and in the maternity home 5.5 hours—values which are statistically significant. It is difficult to find statements in the literature with regard to the average duration of labour in uncomplicated cases. The textbook figures of 18 hours for primigravidae and 12 hours for multiparae are generally taken as "normal." In the present series of cases those delivered in hospital would most nearly approach this. Abnormal cases were included among the observations made by Bromberg and Brzezinski,⁵ and Dieckmann and others,¹ so that comparison with their results is hardly profitable.

The "elderly primigravida" has always been a source of anxiety to obstetricians, and in discussing the average duration of labour among the cases shown in Table II, it is of interest to observe that among primigravidae over 35, the delivery averaged 14.8 ± 1.97 hours, a short time compared with the other age groups. Although the observations were made on a small

number of cases (10), it is worth noting that a completely normal "elderly primigravida" need not necessarily be many hours in labour. The 17 additional cases in this group originally all showed some obstetric abnormality and were therefore

that a hospital would tend to admit difficult cases more readily. A possible explanation lies in the difference in antenatal routine, especially the period of supervision in the antenatal hostel enjoyed by 1 of the 2 groups. If this explanation is correct, it

TABLE II.
Mean Duration of Labour in Hours.

Age group	Hospital cases	Maternity home cases	Difference Hospital—Maternity home
<i>Primigravidae</i>			
15-25	17.83 ± 1.29	11.96 ± 0.59	5.87 Highly significant
26-35	17.25 ± 1.49	13.96 ± 1.35	3.29 Not significant
36+	14.80 ± 1.79	*	
All ages	17.46 ± 0.93	13.12 ± 1.43	4.34 Highly significant
<i>Multiparae</i>			
15-25	13.12 ± 4.66	6.45 ± 0.85	6.67 Significant
26-35	10.01 ± 1.37	7.96 ± 0.74	2.05 Not significant
36+	11.63 ± 1.97	7.56 ± 1.31	4.07 Not significant
All ages	10.73 ± 1.08	7.60 ± 0.55	3.13 Highly significant

* Numbers too few for analysis to be profitable.

excluded from the calculations. This high percentage of complications in this age group is in accordance with observations made by others (Nathanson,⁶ Walsh and Kuder⁷). Kuder and Johnson,⁸ in a study of 830 primiparae over 35, found that the average length of labour was 20.41 hours, with 66 per cent complications. A search of the literature has failed to produce any figures on the normal "elderly primigravida."

Table II also shows that for multiparae and primigravidae the mean duration of labour is significantly longer among the hospital than in the maternity home cases. This is most marked among primigravidae aged 15 to 25, where the values are 17.83 and 11.96 respectively. This is a highly significant difference. As all complicated cases have been excluded from the tables, this difference cannot be explained by the fact

is reasonable to expect the duration of rest to be correlated with the duration of labour. The relation may be linear or curvilinear, if, for example, residence up to a certain point is favourable, while longer periods have little extra effect. Consequently the mean duration of labour for differing periods of antenatal residence was calculated among the primiparae aged 15-25 delivered in the maternity home. The results, which are given in Table III, are surprising because a positive correlation is shown.

For a period up to 9 days the mean duration of labour is 7.64 hours, while for women who were in the hostel more than 40 days the duration of labour was 13.71 hours—80 per cent greater. The correlation coefficient between the two variables was +0.272 which, though not a large value, is statistically significant. For the

older primigravidae and for the multiparae, the correlations were also positive, but not to a significant degree.

In the report on "Women in Industry" made in 1919, the conclusion is reached

it is of interest to consider whether there is any correlation between duration of labour and the month of pregnancy in which work ceased in the present series of cases. The correlations are shown in Table IV.

TABLE III.
Primigravidae aged 15-25 years.

No. of days spent in antenatal hostel	No. of cases	Mean duration of labour (hours)
0-9	11	7.64
10-19	17	10.94
20-29	22	11.46
30-39	15	12.00
40+	7	13.71

TABLE IV.
Correlation Between the Duration of Labour and the Month of Stopping Outside Work in Normal Primigravidae.

Age group		Hospital		Maternity home
15-25	-0.178	Bordering on significance	0.085	Not significant
26-35	-0.111	Not significant	-0.102	Not significant
36+	-0.103	Not significant		
All ages	-0.148	Bordering on significance	0.076	Not significant

that light factory work is not prejudicial to pregnancy. Eastman¹⁰ supports this view and indicates the desirability of employment with adequate precautions up to 6 weeks before term. The difficulties involved in making reliable observations on this matter in factories are pointed out in papers by both Silverman,¹¹ and Olsen,¹² who considers the first 3 months to be the most hazardous, and the middle 3 months to be the safest in industry. O'Sullivan and Bourne¹³ indicate the lack of standards in industry relating to supervision during pregnancy. They studied 90 cases in which antenatal arrangements were satisfactory. Normal deliveries occurred in 77 cases which were followed up.

In view of the controversy, more apparent during wartime, over the optimum time at which to stop work during pregnancy,

None of the values are of definite statistical significance, but the fact that they are mainly negative in sign suggests that too early cessation of outside work is not always favourable to short labour. Further observation and research is required on this important subject.

BREAST FEEDING

Records were available only for the first fortnight of the child's life. Unfortunately, it was not possible to follow up these patients after discharge from hospital, and the study of breast-feeding after the first 2 weeks had to be abandoned.

The findings are given in Table V, which shows the classification of the babies of primigravidae admitted to the maternity home, according to the length of residence

in the antenatal hostel and varying ability to breast feed during the first fortnight.

The distributions are very similar, and, when the appropriate statistical test was made, it was found that there was no evidence to show that the time spent in the antenatal hostel is a factor of importance in breast feeding during the first fortnight

that there was a small negative regression of the birth-weight on age for primigravidae, but the present data are based on too-small numbers for comparison.

DISCUSSION.

The total numbers in both hospital and maternity home groups are adequate for

TABLE V.

Type of feeding	Duration of residence in days			Total
	0-19	20-29	30+	
Breast fed	25	33	25	83
Breast fed with supplement ...	6	5	9	20
Bottle fed	5	7	6	18
Total	36	45	40	121

of life. A similar result was obtained when the month of stopping outside work was considered.

BIRTH-WEIGHT.

The mean birth-weights of the babies for primigravidae in both places are given in Table VI.

statistical analysis, but when these groups are subdivided according to the age and parity of the mothers, the small numbers among the primigravidae over 35, and the multiparae under 25, are noticeable. Any conclusion drawn from these groups must therefore be accepted with caution. It would have been of great advantage if more

TABLE VI.

Age of mother	Sex	Hospital cases		Maternity home		Difference Hospital—Maternity
		Number	Weight in pounds	Number	Weight in pounds	
15-25	M	58	7.40 ± 0.11	30	7.36 ± 0.12	0.04
26+	M	42	7.24 ± 0.13	21	7.57 ± 0.18	-0.33
15-25	F	59	7.24 ± 0.11	27	7.27 ± 0.11	-0.03
26+	F	45	7.23 ± 0.13	17	7.20 ± 0.19	0.03

This table confirms the observation made by many others that boys are heavier than girls at birth. But there is no evidence that the antenatal routine has any influence on the birth-weight of the baby in either group, as the differences shown in the table are not significant.

The relationship between the age of the mother and the birth-weight of the child has been studied by Martin.¹⁴ He showed

subjects could have been included in the investigation, but unfortunately this was not possible, as the antenatal hostel and maternity home closed in the middle of 1945.

That there is a difference between the length of labour of cases delivered in the two places is apparent, but the reason for this difference, which at certain ages is marked, is not so obvious. As far as could

be ascertained the 2 groups were alike, and their treatment during delivery was similar. There is one point which must be considered, and that is the question of medication during labour. Gas and oxygen was used in practically every case for the actual delivery, but it is quite possible that analgesic drugs were used to a greater extent in the hospital cases. Every patient reacts differently to drugs, and this brings in the individual human element which it is impossible to assess, even though the same drugs were used in both hospital and maternity home. It is difficult to believe that the giving of drugs alone would have made such a marked difference in the average length of labour.

There is, then, the question of residence in the antenatal hostel, the most obvious factor in which the 2 groups are unlike. It alone cannot account for the fact that the mean duration of labour was significantly longer amongst the hospital cases. For, when the period of residence was correlated with the length of labour in the primigravidae admitted to the maternity home, it was found that the longer this period, the longer the labour. This was especially true among the mothers under 25. Over this age the correlation was not significant. Whether this finding can be accounted for on psychological grounds is debatable, but it is possible that in the maternity home the fact that everyone was undergoing the same normal physiological process, and that the atmosphere was not austere, contributed towards a shorter labour than that found in the hospital wards, where there was necessarily a more rigid discipline. Again, too long a period at the hostel with few responsibilities may not be beneficial, as it allows more time for vague fears, or for anxieties in connection with absence from home, to accumulate. Fear is believed to be an inhibiting factor during delivery and is often manifest, in other circumstances

than labour, as failure to relax or as positive spasm in both skeletal and plain muscle.

If the explanation for the differences found in the length of labour between the 2 age groups has a psychological origin, as has been tentatively suggested, further research to elucidate the problem will be needed. A longer follow-up of patients is also desirable.

SUMMARY AND CONCLUSIONS.

Two groups of normal maternity cases were compared in the following particulars: length of labour, and birth-weight of child. One group was admitted in labour and delivered in hospital; the other group had had a period of residence in the antenatal hostel before admission to a maternity home for delivery. The ability to breast-feed during the first 2 weeks of the infant's life is considered in its relation to the duration of antenatal residence in primigravidae.

The mean duration of labour was significantly longer in the hospital series, both for primigravidae and multiparae. No significant difference was found in the birth weights of the infants. No significant difference in the initial ability to breast feed in relation to the duration of antenatal residence was revealed.

The difference in length of labour could not be accounted for by the duration of antenatal residence, for among the primigravidae aged 15 to 25 a significant positive correlation was found between length of labour and days of residence.

It is suggested that the findings might be accounted for on psychological grounds, but further research is required for proof.

ACKNOWLEDGMENTS.

It is a pleasure to record our thanks to Dr. H. C. Jennings, Medical Officer of Health, Oxfordshire County Council, for permission to make these observations at

the Emergency Maternity Home, to Dr. Patria Gairdner who helped to launch the investigation; to Professor Chassar Moir and Mr. J. Stallworthy for allowing us facilities at the Radcliffe Infirmary; and to the Nursing Staffs at both places for their willing co-operation. We are indebted to Dr. W. T. Russell for statistical advice, and to Professor J. A. Ryle for help and criticism.

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Full-Time Secondary Abdominal Pregnancy with Delivery of Living Child

BY

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THE delivery of a full-time living child after a ruptured ectopic gestation is very rare. Only 20 cases had been recorded up to 1935 and in many of these cases the child died soon after birth¹. The following case is therefore worth noting.

The patient, a Hindu woman aged 28, was admitted from the Out-patient Department on August 25th, 1944, because of slight pelvic contraction and non-engagement of the foetal head, in spite of the fact that she had reached term and was a primigravida.

Her pelvic measurements were: intercrural 9 inches, interspinous 8 inches, external conjugate $6\frac{1}{2}$ inches, intertuberous $3\frac{1}{2}$ inches—not unusual ones for a patient of her race. The foetal head could be felt below the umbilicus and the limbs were easily felt anteriorly and to the right. Foetal heart heard to the left of the umbilicus. Otherwise nothing abnormal was found on general or local examination.

By 3.15 a.m. on 26th October, 1944, labour pains, which had started at 11 p.m. the day before spontaneously, had become severe and frequent and the patient was sitting up in bed and crying out.

At 3.30 a.m. abdominal examination showed a tender abdomen, head still above the brim of the pelvis. On vaginal examination the os admitted 1 finger; membranes or foetal parts were not felt. The promontory was not felt but the pelvic brim was found to be rather narrow in its transverse

diameter. A thick white mucoid discharge was seen on the examining finger.

Morphia gr. $\frac{1}{8}$ and atropine gr. $\frac{1}{100}$ were then given. At 5.30 a.m. when I saw the patient for the first time, she was getting strong pains almost continuously without engagement of the head or dilatation of the cervix. The presenting part could not be felt *per vaginam* and fluid was not being passed. *Per abdomen*, apart from the head felt prominently bulging in the left lower quadrant, the other foetal parts were obscured by straining efforts on the part of the mother and the tenderness of the abdomen. Foetal heart-rate 150 per minute. Mother's pulse 94, temperature 99° F.

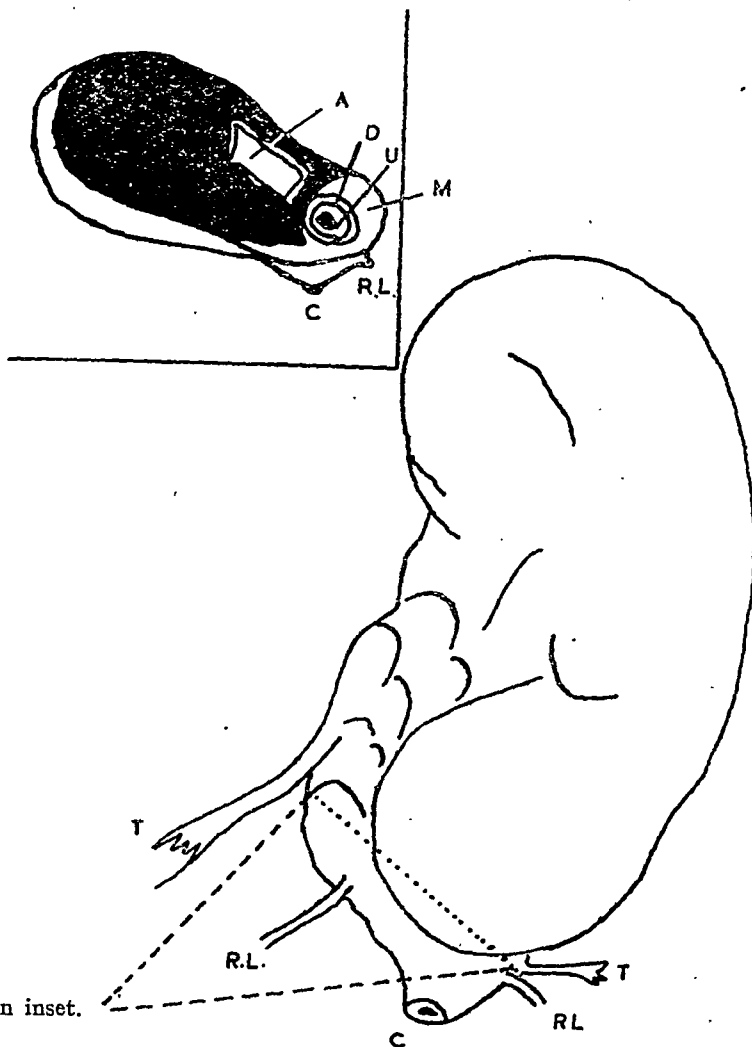
The diagnosis was made of malpresentation due to a soft tissue tumour or twin preventing engagement of the head.

Under local novocaine and light ether-chloroform inhalation anaesthesia a sub-umbilical incision was made with a view to performing a lower segment Caesarean section. On opening the abdomen a little bloodstained fluid appeared and the condition of affairs depicted in the drawing was seen (Fig. 1).

The child, completely covered with its smooth opaque gestation sac and membranes, was lying in the first vertex position entirely outside the uterine cavity, with the head in front and to the left of the uterus, which was itself tilted to the left and posteriorly. The placenta could be made out

through the membranes, attached to the posterior wall of the uterus in the region of the fundus and right cornu. The right Fallopian tube, round ligament and ovarian ligament entered the gestation sac here

inserted almost together into the left cornu of the uterus, which was well down in the true pelvis; and the uterus here looked like an ordinary puerperal uterus about the 4th day of the puerperium.



Plan of section inset.

Diagram of child lying inside membranes.

T, Tube; RL, Round Ligament; C, Cervix; A, Amniotic Cavity;
D, Decidua; U, Uterine Cavity; M, Muscle.

widely separated from one another. The distance between the insertions of the ovarian and round ligaments was at least $2\frac{1}{2}$ inches.

On the left side the 3 structures were

After packing off the intestine and dividing a few omental adhesions the membranes were incised and a living child (7 pounds, male) was easily delivered and cried at once. It was perfectly formed.

The placenta could now be seen filling the whole of the right lower half of the gestation sac and so intimately fused with the structures in the region of the right uterine cornu that it seemed to form a part of the right uterine wall here.

As the uterus was obviously of no further use as such it was removed by subtotal hysterectomy, together with the right tube, ovary, placenta and membranes, and the abdomen was closed. There were only a few fresh clots in the pelvis at the end of the operation. The small intestine contained many round worms.

Puerperium. This was quite afebrile except for a rise of temperature to 99.6° F. on the second day. The patient was able to feed her baby and left hospital, with the wound well healed, on the 18th day, the baby having gained 4 ounces in weight.

On going carefully into the previous history of this patient after the operation, she said that in her village, when about 4 months pregnant, she suddenly felt faint and fell to the ground. This was followed by pains in the abdomen for about 2 days but she had no vomiting or vaginal bleeding. From the 7th month onwards she had had occasional pains in the right lower quadrant of the abdomen. She made only one visit to the antenatal department when she was at term and was then admitted.

Pathological Report. The specimen shows a puerperal uterus amputated in the region of the internal os, with the right Fallopian tube, ovary and stump of the right round ligament attached to it at widely separated intervals of over 2 inches on the right side. The stumps of the left tube, ovarian and round ligaments are inserted close together in the normal way on the left side. The right border of the uterus is 4 times as long as the left, measuring from the cervical canal to the tubal insertion, and is largely made up of the tissues of a full-time placenta which has infiltrated and destroyed

the musculature in the region of the right cornu. The placenta spreads across the uterine cavity to the left and posterior aspects and forms the floor of the gestation sac, which is completed by the amnion and thickened chorion laeve. Pieces of omentum are adherent to the latter at one or two places. The main part of the uterine cavity is not occupied by placenta and is lined by decidua about $\frac{1}{4}$ inch thick, pale in colour and showing no haemorrhages.

Fig. 1 is a drawing showing the appearances at laparotomy. Inset is drawn a cross section of the specimen from below the insertion of one tube to below the insertion of the other. In this the smaller, thick-walled pale end shows the main uterine cavity (U), decidua (D) and uterine muscle (M). The dark and large end is the cut placenta. At about the junction of the 2 and rather nearer the posterior surface (upper part of the diagram) a portion of amniotic cavity (A) has been cut through and shows as a rectangular cleft of the drawing.

Histology. The report of Dr. J. G. Parekh, M.R.C.P., Pathologist, Sir Jamssetjee Jeejeeboy Hospital, was that no uterine muscle could be found in the region of the right tubal insertion. Here it had been entirely replaced by the chorionic villi and blood sinuses of the placenta.

Other sections showed a normal uterine muscle and decidua lining the unoccupied uterine cavity and a gradual thinning out and disappearance of the muscle as the gestation sac is approached.

Comment. The chief interest of this case lies in its rarity. According to Mall² less than 1 per cent of all cases of ectopic gestation go to term. In Wilson's case¹ the baby weighed 5 $\frac{1}{4}$ pounds and was estimated as of 8 $\frac{1}{2}$ months gestation. He states that up to 1935 there were only 40 recorded cases of delivery of an abdominal pregnancy at term and of these only 20 children were

born alive. One surprising thing about these reported full-time extrauterine pregnancies is that in many the child was found free in the abdominal cavity and not surrounded by its membranes, that is, development had continued in spite of rupture of the amnion. The late Colonel Plumptre, I.M.S., told me of one such case he had had in his early days in Kathiawar (unpublished), when the baby's back presented in the abdominal wound made at the operation for Caesarean section. He started to incise this, thinking it to be the uterus. It was not till ribs were encountered that the true condition was discovered. Mother and child both recovered uneventfully.

Other cases reported include those of Bogdamvics³ and Du Bose.⁴ In both there was a simultaneous intrauterine twin pregnancy: and in both the 2 children were successfully delivered alive, but 1 child died soon afterwards. Novak⁵ collected 9 such cases where both children lived.

Apart from its rarity, this case is remarkable for the situation of the rupture, which must have taken place in the interstitial portion of the tube at about the 4th month. This type of rupture is said to be followed by very profuse bleeding and yet at operation only a little pink fluid was found in the abdomen and not many adhesions. It would seem that here the rupture occurred very gradually through the upper part of the tube where the chorion laeve happened to be situated, so that the big placental sinuses were not affected. The placenta then continued to grow at the expense of the uterine muscle since there was no proper decidua in this region to protect the muscle from its eroding action.

SUMMARY.

1. The delivery of a live full-time child in a case of secondary abdominal pregnancy is reported, the ovum being originally implanted in the interstitial part of the tube.

2. It was not an angular pregnancy since the attachment of the tube, round ligament and ovarian ligament would then have been close together on the outer side of the gestation sac and not widely separated as in this case.

3. A brief review of the literature is made.

I have to acknowledge the great assistance of the House Surgeon, Mr. J. A. Castellino, M.B., B.S., both for his pre-operative notes and his help at the operation. My thanks are also due to Dr. J. G. Parekh, M.R.C.P., who prepared the histological sections and reported on them, and the College artist, Mr. R. G. Gupte, who took the photographs from which the drawings have been made.

I have to thank also Lt.-Col. Jelal M. Shah, O.B.E., I.M.S., for permission to publish this case.

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ROYAL COLLEGE OF OBSTETRICIANS AND GYNAECOLOGISTS

D.Obst.R.C.O.G. Examination, March 1946

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INDEX TO CURRENT LITERATURE

In this Index an endeavour will be made, so far as conditions permit, to maintain an up-to-date record of all titles bearing on obstetrics and gynaecology and the infant. The classification aims at making immediately available for the reader the titles under the various subject headings. In the majority of instances the title is obtained from the original publication. Where this has been impossible, the title has been obtained from the abstracting journal shown in brackets. Reprints will be welcomed and should be sent to the Editor.

Any inquiries should be addressed to Miss D. F. Atkins, British Post-graduate Medical School, Ducane Road, London, W.12.

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Some Gynaecological Aspects of Referred Pain

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IN this paper I propose to give a modified report of part of the work I published in 1941 in the form of a monograph.¹ Evidence will be adduced to support the view that pain can arise and be provoked in an abdominal organ, that this pain is independent of any involvement of the peritoneum or arteries, and may be abolished by anaesthetizing the area of skin to which it is referred. In order to explain these and other facts I suggested a new hypothesis. A more complete study of the wider problem of pain is afforded by Lewis² in his monograph published a year later, in which he gives a lucid and penetrating review of the literature, and incorporates the important contributions he made to this problem in association with Pickering, Pochin, Kellgren, and others. He arrived at a conclusion with regard to the central reference of referred pain which is not dissimilar to that I advanced.

Pain is a purely subjective, and consequently unmeasurable phenomenon which largely subserves a protective function. It

is therefore not surprising that the great majority of sensory nerve endings are located in the skin, the protective covering of the body. All peripheral sensations may be ascribed to one of the four specific systems; touch, pain, warmth and cold, and while all sensory impressions reach the spinal cord through the posterior nerve roots, each system traverses a separate pathway to the sensorium.

The posterior root divides into a number of rootlets which enter the cord in the line of the postero-lateral sulcus, and then divide into medial and lateral filaments. The small fibres of the lateral filaments, which are thought to contain the pain-conveying fibres, pass into Lissauer's tract, where, after a short course, they end in the substantia gelatinosa of the posterior horn. New neurones, arising in this substance, cross the mid-line and travel in the spinothalamic tract to end in the lateral nucleus of the thalamus. The fibres mediating temperature likewise cross to the opposite side shortly after entering the cord. It is

not yet determined whether pain has any true cortical representation, but it may be observed that there is no reason to suppose that direct stimulation of the cells of a pain apperception centre in the cortex, if it existed, would cause pain. We do know that section of the pain fibres running in the spinothalamic tract does not cause pain.

Superficial, or skin pain may be caused by pinching, and pricking, by adequate heat or cold stimuli, by electrical stimulation, and by other mechanical means, but rarely, and this is surely significant, without causing injury to cells. This is one feature which distinguishes superficial pain from tactile and thermal sensation. It is also possibly a feature which distinguishes it from some forms of visceral pain.

The threshold to pain may be lowered by both central and peripheral factors. A savage clearly feels pain less than a civilized man, and modern western civilization, with its restless bustle and noise, its anaesthetics and its aspirin, is responsible for a large and increasing number of people becoming hypersensitive to it in all its forms. Illness, overwork, worry, a vivid imagination linked with unhealthy anticipation, sleeplessness, dissipation of all kinds and the excessive intake of alcohol increase sensibility to pain, as do certain drugs. It is decreased by old age, loss of one or more of the senses, the attainment of mental equilibrium in association with physical fitness and by a considerable number of drugs. At rare intervals apparently normal individuals are encountered who are insensitive to most forms of pain, and are not even aware of discomfort when a tooth is extracted. Indeed, if reports can be believed, Cossacks and other peoples of Russia are almost incapable of feeling pain, as were the old guards who served under Napoleon.

Peripheral factors, such as a minor degree of local injury or an alteration in tension, such as may be effected by chang-

ing the position of a limb, may also alter the threshold to pain.

Lewis² has dealt exhaustively with the local factors associated with cutaneous hyperalgesia and hyperaesthesia. It is possible that a generalized cutaneous hyperaesthesia may be central in origin. After an attack of malaria I have found the whole of my skin, including the scalp, hyperaesthetic. While this condition lasted drops of water falling on the body from a shower bath caused an unpleasant sensation, as did the subsequent towelling if it was lightly done; and electrical stimuli, which were normally hardly appreciated, became distinctly painful.

Superficial pain is described as pricking, stabbing, or burning, and can be localized with great accuracy. Accuracy of localization is normally aided by the tactile sense, by vision and by experience. Pain arising in muscle, tendon, bone, periosteum, joint and other mesodermal structures is of a different quality and is often described as sickening. It may, indeed, cause emesis. Lewis points out that this type of pain may be caused by squeezing the web between two fingers. Visceral pain belongs to this deep type of pain although it is referred to the surface of the body. Pain cannot be measured, but it is possible to obtain evidence concerning its severity, quality, localization, duration, and its time-intensity curve. Pain is soon forgotten and the best evidence is therefore to be obtained in recurrent types of pain, or while the pain is actually being experienced.

Referred pain is pain which is appreciated at a point distant from the organ or structure in which it arises. The term was first used by Head³ in 1893, in relation to pain arising in diseased viscera. Visceral pain has provided fascinating problems, provoked much discussion, and given rise to varied and mutually contradictory hypotheses, and for two main reasons. In the

first place it is known that the heart, lungs, liver, spleen, kidneys, stomach, gall-bladder and intestines are insensitive to stimuli which cause pain on the surface of the body.⁴ Nevertheless we know that pain from the heart may be very severe, and be referred to the front of the chest, to the neck, down the left arm; that appendicular may be appreciated just to the left of mid-line, at or above the level of the ilicus; that pain from the fundus of bladder is referred to the lower abdomen, while that from the trigone is referred to the tip of the penis; that pain from the testis is referred down the right side of the scrotum and to the testicle of the same side; that intestinal and renal colic are the most intense pains that man is called upon to endure. The first reason for confusion heretofore, is that intense pain originates in structures that are insensitive to ordinary pain-producing stimuli.

The second reason is that the sympathetic nervous system has been accorded both an anatomical and a physiological connotation. The classical work of Langley and Gaskell has been so interpreted in physiological textbooks as to convey the impression that the sympathetic nervous system consists entirely of efferent nerves. These two physiologists concerned themselves chiefly with the motor effects produced by stimulation of sympathetic nerves, nevertheless the erroneous thesis, improperly attributed to them, dominated both physiology and medicine for well nigh a quarter of a century, and received clinical support from the studies of Lennander. This is all the more surprising when it is remembered that Sherrington was well aware of the fact that the sympathetic nervous system included sensory fibres, and that Dogiel had described sympathetic sensory proto-neurons in 1895.

The views ascribed to Langley and Gaskell were challenged and disproved by

clinicians, notably by the French surgeon Leriche, on the following evidence. The smaller arteries are sensitive to puncture, and pain is usually felt when they are clamped or tied. The pain associated with Raynaud's disease and causalgia may be abolished in some cases by periarterial sympathectomy.⁵ Jonnesco⁶ and Ionescu⁷ have found that the mechanical stimulation of both the cardiac nerves and the inferior cervical ganglion causes pain. Leriche and Fontaine⁸ have caused pain in the jaw and behind the ear, by stimulating the superior cervical ganglion, notwithstanding the fact that the sympathetic chain above this level receives no white ramus and has generally been considered to be devoid of afferent fibres. Stimulation of the central end of the splanchnic nerve also causes severe pain.

In recent years the sensory side of the sympathetic nervous system has attracted the attention of physiologists, and in this country McSwiney and his fellow-workers have been the pioneers. Miller and Simpson,⁹ and McSwiney and Suffolk,^{3,10} have afforded physiological evidence which supports the view that afferent impulses from the viscera pass through the posterior nerve roots into the cord, the former workers using muscular reflexes, and the latter, dilatation of the pupil as their guide. It is therefore proved that the sympathetic nervous system includes sensory nerves, and almost certain that they enter through the posterior nerve roots into the cord, but nothing definite is known concerning their subsequent course in the spinal cord. The fact that double cordotomy affords immediate relief of pain to sufferers from malignant growths of the viscera, suggests that they travel with the somatic pain fibres in the spinothalamic tracts. Although the existence of these sensory nerves (which I shall refer to as "visceral-afferent nerves travelling in visceral-afferent pathways") has been recognized, the isolated

instances of pain caused in viscera by surgical interference (such as that caused by the tip of the ureteric catheter when it is pressed against the wall of a renal calyx) have hitherto not sufficed to disprove the contentions of Lennander.

Bearing these considerations in mind it is easy to trace and to understand the reasons for the varied and mutually exclusive hypotheses which have been advanced to explain visceral pain. Although Hunter recorded that an animal could eat its food with relish while its viscera were being burned, it was not until 1883 that Sturge¹¹ made the first attempt to explain referred pain. Puzzled by the reference of cardiac pain to the left arm he came to realize that the "region of the spinal cord which gives origin to the brachial plexus gives origin also to the greater part of the fibres which eventually find their way to the heart." He came to think of a small area of commotion occurring in the cord, which was extended by the mediation of commissural interpolar fibres, which connect the cells one with another, and suggested the analogy of epilepsy, which was striking, if not altogether convincing. Sturge therefore postulated a true visceral or "splanchnic" pain, and a pain which was referred from the viscus in the manner outlined above. Ross¹² accepted these ideas.

Lennander,⁴ however, after very thorough investigations, concluded that all the abdominal viscera were insensitive to burning, cutting, squeezing and other noxious stimuli, and that consequently no pain could arise in them. He postulated the more simple explanation that the sensation of pain associated with disease of the abdominal viscera arose in the peritoneum, its sub-serous coat, and, when inflammation was present, in the root of the mesentery; all these structures being supplied by somatic nerves. Mackenzie,^{13, 14, 15} was convinced by Lennander's evidence con-

cerning the insensitivity of the abdominal viscera, but was equally impressed by the reference of cardiac and appendicular pain. He was therefore driven to assume that the ordinary non-painful stimuli from the viscera could, when quantitatively increased, set up a focus of irritation in a segment of the spinal cord and thus indirectly stimulate sensory nerves. The pain so caused was referred to the cutaneous areas supplied by those nerves. Mackenzie, Ross, and Sturge, as I understand them, believed the sensory nerves to be stimulated proximal to their endings. According to this view local anaesthetization of the cutaneous areas involved could have no effect on the pain.

More recently Morley¹⁶ has supported the underlying conception of Lennander's hypothesis, although he believes in the existence of a true visceral or "splanchnic" pain. He affirms that both referred pain and abdominal rigidity arise as the result of irritation of the somatic nerves which supply the parietal peritoneum, which he postulates to be very sensitive. He found, during the course of operations under local anaesthesia, that irritation of the diaphragmatic peritoneum with gauze caused shoulder pain on the same side, and that this pain could be abolished, or significantly lessened, by anaesthetizing the skin of the area to which it was referred. Escaped blood from an ectopic gestation causes shoulder pain, as may the CO₂ used for the insufflation of the Fallopian tubes. The diaphragmatic peritoneum is indubitably very sensitive, even to gas, but there is no justification for Morley's assumption that the rest of the parietal peritoneum is equally sensitive. Indeed, other observers have reported that the parietal peritoneum is insensitive to all forms of sensory stimuli. Woolard, Roberts and Carmichael¹⁷ subsequently reported that direct stimulation of the phrenic nerve by pinching caused

severe shoulder pain, and that the previous anaesthetization of the cutaneous area to which it was referred in no way affected the character, or lessened the intensity of the pain. These authors do not indicate very clearly what steps they took to ensure cutaneous anaesthesia of the shoulder area, or what success they achieved. Nevertheless, the divergence between the results obtained by Morley on the one hand, and Woolard, Roberts and Carmichael on the other, does not necessarily diminish their significance, for it could reasonably be attributed to the difference in the intensity of the stimulus they severally applied.

Hurst¹³ came to believe in a true visceral tenderness, and concluded from X-ray examinations that the gastric ulcer is as a rule the seat of localized tenderness, and that the point of actual tenderness changes with alteration in the position of the ulcer occasioned by altered posture. Morley and Twining¹⁶ confirmed Hurst's findings, but drew therefrom quite different conclusions. Whereas Hurst believed the ulcer itself to be tender, the former workers hold the parietal peritoneum covering the ulcer to be the seat of the tenderness.

In an attempt to explain the insensitivity of the viscera to stimuli which cause pain on the surface of the body, Hurst suggested that just as the ear was insensitive to light, and the eye to sound, so the intestines were insensitive to cutting, pinching, or burning, but that they were sensitive to stimuli which caused increased tension in their musculature. This conception of an adequate stimulus has proved valuable, but the form in which it was expressed offers grounds for criticism. Sensory nerves are all much alike and vary only with regard to the speed with which they conduct impulses, a variation which may possibly be correlated with the area of cross section. It is the nerve endings which are of real significance, those at the periphery being designed to

collect stimuli of a certain nature, while those at the centre are responsible for their interpretation. A nerve fibre which conducts the sensation of cold can be stimulated by heat, but the sensation appreciated will be that of cold.

Finally, it may be recorded that Weiss and Davies¹⁷ concluded that the direct stimulation of a viscus without affecting other structures, was beyond the bounds of possibility. They therefore attacked the problem indirectly, and assumed the possibility that a focus of irritation was caused in a segment of the cord by the "bombardment" of non-painful stimuli from the diseased viscus, and that the normal stream of impulses from the cutaneous areas to which the pain was referred, were rendered painful when they entered this focus of irritation. They found that anaesthetization of the cutaneous areas to which the pain was referred abolished visceral pain, and concluded that this observation supported Mackenzie's hypothesis.

It is my contention that the gynaecologist enjoys unique opportunities for studying the problem of referred pain. All are agreed that the uterus is an abdominal viscus innervated in the same way as are the other abdominal viscera. More than half the women in Europe, America, and Australia suffer, or have suffered from some degree of pain at monthly intervals. Dysmenorrhoea occurs in perfectly healthy women, and with such regularity that they are able to record their sensations with precision. The pangs of childbirth, in some degree or another, accompany the birth of nearly every child. Thus, concerning no other type of pain is there anything approaching the wealth and completeness of the clinical data, as that which has accumulated from all civilized countries on the subject of uterine pain.

The uterus is not so insensitive to ordinary painful stimuli as is commonly

PART I.

DYSMENORRHOEA.

asserted, and it seems to me that gynaecologists have been unduly influenced by the oft-repeated assertions of the insensitivity of the viscera. It is true that the fundus uteri may be painlessly incised, but it is not true that the volsellum may be painlessly applied to the lip of the cervix. Most women dislike the application of this instrument, and although the stab of pain is shortlived it is none the less unpleasant. Removal of a piece of tissue from the external os uteri, whether with scalpel or scissors, causes considerable pain, as does the insertion of a ligature to control haemorrhage. The neighbourhood of the internal os is often sensitive to a probe, and it is rarely possible to curette the uterus, however gently the operation be performed, without causing quite severe pain. Further, cervicitis often causes movement of the cervix in any direction to be painful.

These clinical observations are very valuable, but the most important fact is that uterine pain, in no way differing from dysmenorrhoea, or the pains of labour, may be occasioned by a simple procedure. Some 10 years ago²⁰ I began to treat endocervicitis by the application of a stick of silver nitrate, and this method of treatment unexpectedly afforded a simple means of provoking and studying pain referred from the cervix and the body of the uterus.

It is therefore proposed to consider this problem in two parts.

(1) UTERINE PAIN.

- (a) As it occurs in normal healthy women, namely dysmenorrhoea.
- (b) As provoked by the application of a stick of silver nitrate to the cervical mucosa and endometrium.
- (c) As it occurs during labour. Observations on the relief of these pains by local anaesthesia will be recorded.

(2) OBSERVATIONS ON THE VISCERO-MOTOR REFLEX.

In England, menstruation most commonly commences during the 14th and 15th years of life, and it is probable that the menarche occurs either before or after that period of life in less than 15 per cent of girls.²¹ At their onset the menses are often irregular, and the interval between the first and second period may exceed a year. The first period is rarely, if ever, painful and it is only after the lapse of one or more years that pain becomes to be associated with the flow. In some of the worst cases of dysmenorrhoea the history of freedom from any menstrual pain for some years after the onset of the menarche is frequently elicited. It may, therefore, reasonably be concluded that the pain is not caused by, or even associated with, structural defects in the uterus.

The pain may commence some hours before the flow, or may not occur until it becomes established. It may last a few hours or may persist for two days or longer. It is usually described as being cramp-like rather than continuous. The pain may be very mild, causing less discomfort than a purgative, while it may be as intense as that normally experienced during labour, and may be associated with pyrexia, a leucocytosis, and even with jaundice. It cannot be attributed to inability of the blood to escape from the uterus, for it is always possible to pass a small metal cannula into the uterine cavity. The pain is most commonly referred to the lower abdomen, but sometimes to the lower part of the back, or over the hips, and still less commonly down the upper third of the insides of both thighs. The pain of dysmenorrhoea may usually, if not invariably, be abolished by anaesthetizing the areas of skin to which it is referred.

In England a small percentage of girls

and women invariably suffer intense pain with each period. They faint, vomit, and have to go to bed, and those who have to earn their living thereby stand in jeopardy of losing their employment. At the other extreme some 20 per cent of women never suffer a twinge of pain or discomfort during menstruation. In between these extremes lies the great majority of women. The pain is usually tolerable and does not interfere with their work or play, but should they do too much, become over-excited, lead irregular lives, or become run down through over-study or any other cause, it becomes severe.

I have found in all cases of dysmenorrhoea that deep palpation over the tip of the left transverse process of the second lumbar vertebra, the point of emergence of the first lumbar nerve, causes pain. The patient may also be sensitive to pressure over the corresponding position on the right side, but in my experience the tenderness is usually either limited to, or more marked on the left side. I have no explanation to offer for this phenomenon, but think it possible that dysmenorrhoea may sometimes be causally related with a slight departure from the structural integrity of the spinal column, of insufficient magnitude to be detected by radiological investigation. This deep tenderness may also be elicited not infrequently in patients suffering from chronic ovarian pain.

The most fascinating and illuminating facet of the problem of dysmenorrhoea is its indivisibility from psychological factors. It not infrequently happens that women who invariably suffer intense menstrual pain enjoy absolutely painless periods when brought into hospital for investigation. The onset of dysmenorrhoea is often associated with a change of work or of environment. In Bangkok there were two large mission schools for girls. In the one, approximately 80 per cent of the girls

went to bed for the first day of the period, whereas in the other less than 20 per cent felt the necessity even to lie down for a while. The class of girl was the same, but the traditions differed. It sometimes happens that a girl ceases to suffer from dysmenorrhoea when she falls in love, and before indulging in sexual congress. Further, this is probably the only type of severe pain which may be relieved by a small amount of whisky or gin.

Primary dysmenorrhoea is almost invariably cured by childbirth, and any subsequent pain is due to chronic infection. It may likewise be cured for a time, if not permanently, by dilating the cervix and incising the "internal sphincter," or by applying the silver stick to the cervical mucosa, although it is of interest to note that the first period subsequent to these operations may be painful. Other means have been successfully employed in the treatment of dysmenorrhoea, amongst which may be mentioned psychotherapy, hypnotism, spinal manipulation, and hormone therapy.

It would therefore seem evident that primary dysmenorrhoea is as independent of structural defects in the uterus as it is dependent, directly or indirectly, on psychological factors. This does not mean that the pain experienced is not very real, and even intense. This aspect of the problem will be discussed later, but it may here be instanced that the pain of dyspareunia, associated with spasm of the introitus, may be very severe notwithstanding the fact that it can as a rule be easily abolished by simple psychological treatment.

THE RESULTS OBTAINED BY THE APPLICATION OF A STICK OF SILVER NITRATE TO THE CERVICAL MUCOSA.

More than 10 years ago I began to treat the endocervicitis so frequently encoun-

tered in the postnatal department by the application of a stick of silver nitrate to the cervical mucosa. The treatment was simple, rapid, painless and reasonably efficacious. Some time later I used the same treatment in the gynaecological outpatient department and was more than surprised to find that it not infrequently caused pain.

Silver nitrate. Salts of heavy metals when applied to mucous membrane precipitate the proteins with which the metals form a complicated adsorption complex. If this adsorption complex is soluble in the acid which is liberated, the metal penetrates deeply into the cells, causing a corrosive action. In the case of silver nitrate the reactions are affected by the formation of silver chloride, but the protein complex is soluble in the excess of nitric acid so that the metal penetrates the tissues deeply.

It is not possible to state to what extent the corrosive action of silver nitrate is to be attributed to the liberated nitric acid, but suitably treated sections demonstrate that the silver penetrates the whole depth of the mucosa, and in particular stains the endothelium lining the blood-vessels. The standard stick used measured 6 cm. in length and has a diameter of 0.5 cm.

The Method of Applying Silver Nitrate.

After the introduction of a Sim's speculum, the anterior lip of the cervix was grasped with a volsellum, and the silver stick was introduced through the external os uteri with a suitable pair of forceps, and then pushed up the canal until the internal os was reached. Except in postnatal patients the silver stick could not at first be introduced through the internal os, because the upper part of the cervix contracted and tended to expel the stick with some force from the canal. If, however, the stick was held in position by the forceps the spasm

disappeared in about 30 seconds. Once the spasm had passed away the stick would lie in the canal, and might pass into the uterine cavity, and only with difficulty be recovered. It was moved up and down against the walls of the cervix for some 2 minutes, after which time it was usually reduced in size by one half. The stick having been withdrawn, the vagina was plugged with gauze soaked in glycerine to prevent the vagina and perineum from being burned.

PAIN.

It is clearly impossible to treat the endometrium with the silver stick without concomitantly affecting the cervical mucosa and for this reason my remarks will be confined to the treatment of the cervical mucosa and of the endometrium in close juxtaposition to the internal os. I would observe, nevertheless, that there is every reason to suppose that the endometrium is as sensitive to the silver stick as is the cervical mucosa. I have already stated that this treatment, except in the postnatal department, frequently caused pain, sometimes of a severe nature. It can be asserted that every woman who suffers from primary, or any other form of dysmenorrhoea will suffer pain as a result of this treatment, and that the pain will be identical with the pain that she suffers during her period, although it may be more severe. With other patients it is not possible to prognosticate whether the treatment will cause pain, but there are three factors which are of significance: (a) the degree of dilatation of the internal os uteri; (b) the social status of the patient, and (c) the thickness of the cervical mucosa.

The degree of dilatation of the internal os uteri. Although there would appear to be no anatomical muscular²² ring at the level of the internal os uteri, clinical evidence

indubitably proves that there is a powerful sphincter closing the cavity of the uterus from the cervical canal. Any effort to stretch this sphincter causes immediate pain. In nulliparae the region of the internal os is particularly sensitive to the silver stick, and if the sphincter be tightly closed it may be opined that the patient will subsequently suffer some degree of pain.

The social status of the patient. The difference in the incidence of pain subsequent to this manoeuvre between the hospital and the higher class of patient is very marked. In my experience every patient of the upper middle class tends to suffer considerable pain as the result of this treatment, which must therefore be carried out under some form of anaesthesia.

The thickness of the cervical mucosa. The shrinkage of the silver stick, and consequently the amount of free silver liberated, is largely dependent on the amount of available fluid, which in turn is determined by the thickness of the mucosa and the amount of secretion present. If treatment be carried out shortly before a period is due the pain will be more severe and likely to last several days. Subsequent menstruation, if it occurs within 48 hours of the application, will be painful even if the individual normally experiences no pain at that time.

The Onset of the Pain.

In the majority of patients the onset of the pain occurred within 2 minutes of the application of the silver stick. In 2 patients the external os uteri itself was unduly sensitive and marked pain referred to the lower abdomen was appreciated immediately it was touched by the silver stick. It is not very uncommon to encounter patches of erosion on the external os which when touched either by the silver stick, or by cotton wool dipped in pure lactic acid, give

rise to a sharp stab of pain referred to one or other side of the lower abdomen. The application of the volsellum to the anterior lip of the cervix may likewise give rise to a similar transient stab of pain. The onset of pain was frequently delayed for 10 minutes, and in one case for as long as 4 hours. The second and third applications of the silver stick were usually accompanied by a diminishing degree of pain.

The Site of the Pain.

In the case of nearly every patient who experienced pain it commenced, somewhat surprisingly, in the middle line, usually at a point about one third of the distance from the symphysis pubis to the umbilicus. From there it radiated across the lower abdomen, so that the whole area below a line drawn between the two anterior superior iliac spines was involved. The pain was commonly localized to this area, but 3 other sites were not infrequently involved: (a) the back; (b) over the iliac crest on either side, about a third of the distance from the anterior superior iliac spine to the vertebral column, and (c) down the inner sides of the thighs reaching for about a third of the distance to the knees. (See Figs. 1 and 2).

These are the identical areas to which both labour pains and the pain of dysmenorrhoea are referred, and the skin covering these areas is supplied by branches of the 1st lumbar nerve. Three different methods have been used for delimiting dermatomes. Sherrington,²³ working with monkeys, cut a number of posterior nerve roots leaving but one isolated root intact, and subsequently investigated the responses to painful cutaneous stimuli. Foerster²⁴ found surgical reasons for adopting the same technique in man. Head²⁵ mapped out the dermatomes by studying the cutaneous eruptions of herpes zoster and

it is interesting to note that his margins are contiguous and not overlapping as were those noted by Sherrington. Kellgren²⁶ mapped the dermatomes of the body by injecting hypertonic saline solution into muscles and into the deep interspinous

silver stick applied to the cervical mucosa resulted in pain which was more or less localized to the lower abdomen of the affected side, and it frequently happened that this treatment permanently cured the condition.

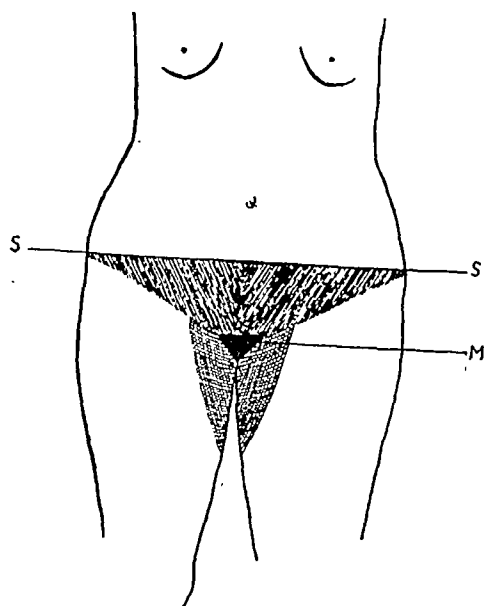


FIG. 1.

S=anterior superior iliac spine; M=mons veneris. The shaded regions indicate the cutaneous areas on the anterior surface of the body to which uterine pain is referred. These areas are supplied by branches of the first lumbar nerve.

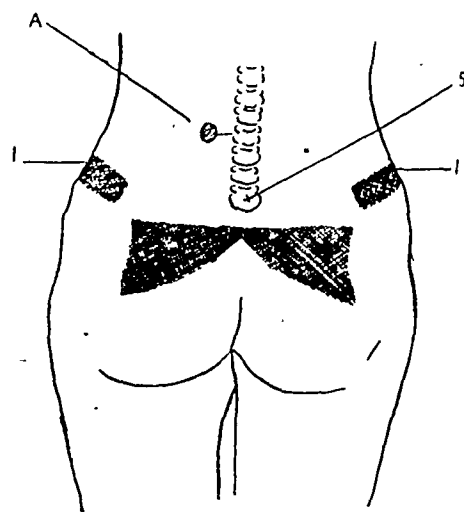


FIG. 2.

I=level of iliac crest; A=the tip of the left transverse process of the second lumbar vertebra; the numeral 5 denotes the spine of the fifth lumbar vertebra. A is the point of emergence of the left first lumbar nerve and this area is usually tender to deep pressure in women who suffer from dysmenorrhoea. The other shaded regions indicate the cutaneous areas on the posterior surface of the body to which uterine pain is referred, i.e. the hips and the back. These areas are supplied by branches of the first lumbar nerve.

ligaments of the vertebral column. So far as I am aware this is the first occasion that the first lumbar dermatome, or any other, has been determined by direct stimulation of a viscus. (Compare Figs. 1, 2, 3 and 4). It may here be noted that in certain cases in which one or other ovary was tender, and the site of chronic ovarian pain, the

The Intensity of Pain.

In some cases the pain caused was intense and more severe than that associated with dysmenorrhoea. The only drug which afforded relief in such cases was morphia, although aspirin was usually reasonably efficacious.

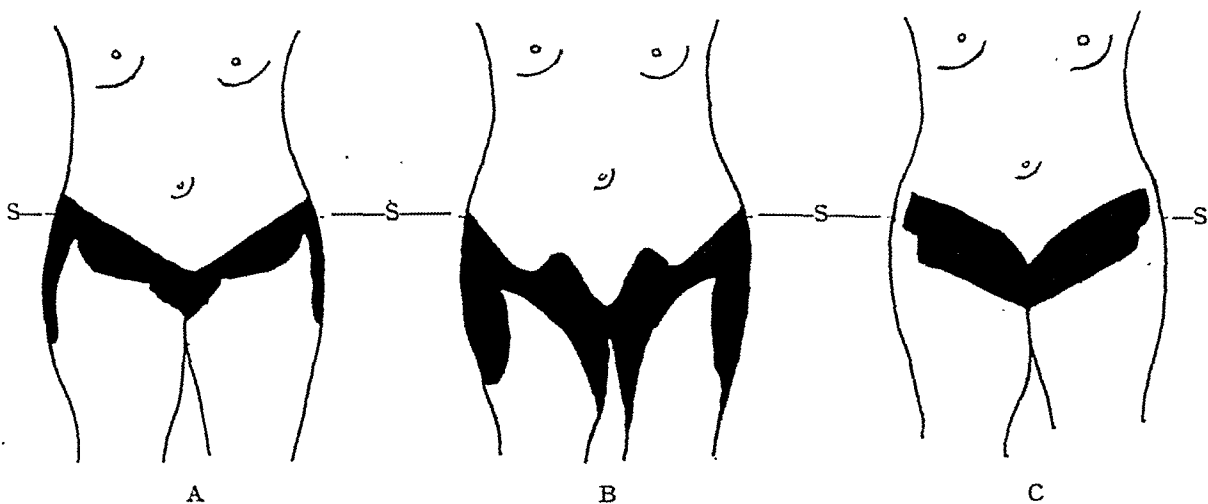


FIG. 3.

The ventral distribution of the first lumbar dermatome: A according to Foerster; B according to Head; and C according to Kellgren. These authors attempted to demarcate all the dermatomes of the body, and it is not easy to be sure of the exact boundaries they intended for any single dermatome. S=Ant. Sup. Iliac Spine.

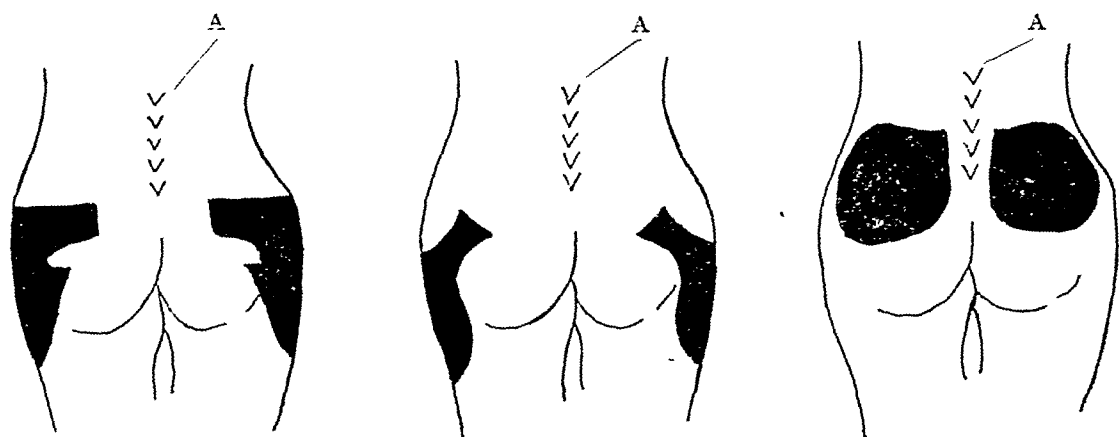


FIG. 4.

The dorsal distribution of the first lumbar dermatome: A according to Foerster; B according to Head; and C according to Kellgren. A denotes lumbar spine.

Cutaneous Hyperalgesia and Hyperaesthesia.

The pain referred to the lower abdomen was frequently associated with an apparent hyperalgesia of the skin, but the severity of the pain made it difficult to make any satisfactory observations. Stroking the affected skin lightly with the finger, or with cotton wool, was considered definitely unpleasant and was sometimes described as painful. It was not found possible to come to any conclusion with regard to any altered perception of heat or cold but in some cases there appeared to be a heightened perception to cold. It can, however, be asserted with confidence that any alteration which may have occurred in cutaneous sensibility disappeared with, and did not outlast the uterine pain.

The Prevention of Pain

It was sometimes found possible to prevent all pain by previously infiltrating the cervical mucosa at the level of the internal os with a 1 per cent solution of novocain, but not always. The discrepancy in the results may possibly be attributable to the fact that the procedure presented considerable technical difficulties. On the other hand it was not found possible on any single occasion to relieve the pain by this procedure after the silver stick had been applied. It is a remarkable fact that if the silver stick be applied while the patient is under a general anaesthetic the subsequent pain is negligible. This is all the more remarkable as the treatment is usually finished before the pain commences. The significance of this observation will be discussed later.

The Relief of Pain Caused by the Application of the Silver Stick.

It has already been stated that the pain caused by this procedure can usually be relieved by aspirin, although it may some-

times be necessary to resort to morphia. It is a somewhat surprising fact that in many cases considerable relief of pain was afforded by removing the vaginal plug, seeing that the sensory supply of the vagina derives from sacral nerves. The pain over the iliac crests could easily be abolished by infiltrating the subcutaneous tissues at the points where the nerves (branches of the 1st lumbar nerve) pass in close relation to the bone. The abdominal pain could usually, but by no means always, be completely relieved for a time by infiltrating the ilio-hypogastric and ilio-inguinal nerves where they pass in close relation to the anterior superior iliac spines, and as a rule the injection of some 10 c.cm. of a 2 per cent solution on either side sufficed. The relief so occasioned lasts for less than one hour, although similar injections relieve the abdominal pain of dysmenorrhoea for several hours, if not completely. The relatively short time of immunity from pain thus procured in these patients may find its explanation in the fact that the pain is continuous, whereas in dysmenorrhoea it is spasmodic. I suggest that the differences encountered in the alleviation of the abdominal pain associated with dysmenorrhoea and that associated with the application of the silver stick to the cervical mucosa has an explanation similar to that already suggested for the divergence in the results recorded by Morley¹⁶ on the one hand, and Woolard, Roberts and Carmichael¹⁷ on the other.

The pain following the application of the silver stick to the cervical mucosa was so strikingly consistent in regard to its onset and distribution that it is not proposed to report cases in detail. A table (Table I) is, however, appended which shows the results obtained in 41 consecutive patients so treated in a gynaecological out-patient department in London, most of whom were in the third decade of life. Only 5 of these

patients came for treatment solely because of dysmenorrhoea, but the majority of women in group 2 suffered from painful menstruation in addition to abdominal pain. It may be recorded that 5 out of the 12 women in this group experienced the most severe pain subsequent to the treatment over one or other ovary. It is also of interest to note that this procedure so frequently caused vomiting, because, except in isolated instances, the pain was

difficultly cured. The intractability of the condition is due to the natural crypts and crevices which occur in the cervical mucosa no less than to the racemose structure of the cervical glands. Infection tends to become locked up in the recesses of the glands in the deeper layers of the cervix, while the consequent swelling of the tissues militates against drainage.

The diagnosis of the condition can be made with ease, and I will quote from his

TABLE I.

Condition treated	No. of patients	No. who felt pain	Site of pain			Severe pain	Vomited
			Abdo.	Back	Hips		
Group 1. Dysmenorrhoea	5	5	4	3	0	4	3
Group 2. Chronic salpingitis and salpingo- oophoritis	12	11	10	4	1	6	5
Group 3. Leucorrhoea, and cervical erosion	21	7	7	2	0	1	1
Group 4. Arthritis	3	2	2	0	0	1	1

not severe. It will be recalled that the 2nd stage of labour is frequently ushered in by emesis. Visceral pain clearly belongs to the deep type of pain.

THERAPEUTIC RESULTS.

This is a convenient point at which to make a brief digression in order to evaluate the therapeutic results of this treatment. Young²⁷ has been the chief exponent in this country of the view that chronic cervicitis may cause pain in the pelvis and lower abdomen, dyspareunia, bladder and menstrual troubles, together with a disturbance of the general health manifested by such symptoms as undue fatigue, headache, arthritis and cardio-vascular disturbances. Cervicitis is easily provoked but with

paper: "If the examining fingers are placed on the cervix and this be moved laterally, antero-posteriorly, and upwards, it is found that in health a considerable amplitude of displacement can be obtained in all these directions, and that even at its maximum this displacement is painless. In cases of cervicitis, on the other hand, this mobility is commonly restricted, and in those cases in which pain is present any attempt to displace the cervix at once provokes the symptom in the location in which it has been complained of by the patient, be it in the iliac fossa, the back, or the bowel." I confess that for many years I considered these claims excessive, and for two main reasons. In the first place I did not believe that such pain could arise in the cervix, and in the second I considered

his arguments vitiated by the fact that obvious cervicitis so commonly occurred without causing any symptoms other than leucorrhoea. I am now satisfied that pain of a severe nature can arise in the cervix, and that the same stimulus can provoke pain in some women and none in others, and can therefore confirm Young's main, and very important contentions.

The symptoms he, and others describe can clearly be attributed to three main factors: (a) toxæmic absorption, (b) local extension of infection, and (c) referred pain.

Toxæmic absorption. It is recognized that arthritis can arise from a gonococcal infection of the cervix and be cured by treatment limited to the cervix. I am satisfied that other forms of arthritis, no less than the other disturbances of the general health above enumerated, can arise from a chronic infection of the cervix. Indeed, there is reason to suppose that chronic cervicitis is the most potent source of chronic infection in a woman.

Local extension of infection. Cervicitis may be primary, and extend through the parametric tissues to involve the pelvic colon, bladder²⁸ and ovaries. Conversely, it may represent an extension, and one of the late sequelae of a generalized pelvic infection. In either case it is easy to understand how such symptoms as dyspareunia, polyuria, and pain associated with the large bowel could arise.

Referred pain. The problem which is particularly relevant to this study, and peculiarly difficult to elucidate, is to what degree the symptoms associated with cervicitis can be attributed to irritation of the cervical nerves. Discussion will here be limited to bladder symptoms. It is beyond dispute that some cases of frequency may be cured by treatment confined to the cervix. Such treatment might indirectly clear up any extension of infection from the cervix to the base of the

bladder. There is, nevertheless, some evidence which suggests that this simple explanation does not represent the whole truth. In the first place amelioration of the bladder symptoms may occur long before the cervicitis is cured, and without any change in the urine, which may contain as many pus cells after the symptoms have cleared up as it did before the treatment was commenced. In the second place the trigone of the bladder is in closest proximity to the cervix, and pain from this part of the bladder is not referred to the suprapubic region. Further, we know that painful haemorrhoids, and haemorrhoids which have been injected, sometimes cause frequency of micturition, and it must be assumed that this symptom so caused represents a "nervous" phenomenon, notwithstanding the fact that pain from haemorrhoids is conveyed by sacral nerves. For these reasons I think it not improbable that frequency of micturition may result from irritation of cervical nerves. This conclusion is strengthened by the fact that chronic ovarian pain may sometimes be cured by the application of the silver stick to an apparently healthy cervical mucosa.

Most authorities are content to treat cervicitis, after the canal has been dilated, with three sweeps of the thermocautery. The advantage of the method I have advocated lies in the fact that the whole of the mucosa is treated, most of which comes away in a cone-shaped "silver slough" some 3 to 5 days later. The treatment itself is not painful, but the subsequent pain demands either that it be carried out under anaesthesia or that adequate analgesic drugs be given.

THE RELIEF OF LABOUR PAINS BY LOCAL ANAESTHESIA.

Apart from the pain occasioned by the stretching of the vagina and vulva, the

pangs of childbirth differ in no way from dysmenorrhoea, except in degree. Low spinal anaesthesia, adequate for operations on the vagina, cervix and rectum, affords no obvious relief to a woman in the 2nd stage of labour, although the pain occasioned by the stretching of the vagina is abolished. On the other hand, the pain associated with the 1st stage of labour may be banished merely by anaesthetizing the skin of the lower abdomen. If at this time the ilio-hypogastric and ilio-inguinal nerves are infiltrated with an adequate amount of a suitable solution of some local anaesthetic as they pass in close relation to the right anterior superior iliac spine, all the pain associated with uterine contractions immediately disappears from the right side of the abdomen. This result I found invariable. If now the corresponding nerves on the left side be similarly anaesthetized, it frequently happens that pain over the iliac crests, hitherto unappreciated, becomes severe. The nerves concerned, as has already been stated, can be easily anaesthetized, and then, curiously enough, pain in the region of the mons veneris and the inguinal canals may be appreciated. It is remarkably easy to abolish pain from one side of the abdomen and from the iliac crests, but it is extremely difficult to eliminate all abdominal pain associated with the uterine contractions. It would seem evident that if pain referred to the distribution of one set of fibres is abolished, it is appreciated in undiminished intensity in areas, hitherto painless, which are supplied by nerves which have not been anaesthetized. Unless all the nerves concerned are anaesthetized the woman is not conscious of much relief of pain.

A similar experience is encountered when attempts are made to treat chronic shoulder pain by the injection of a local anaesthetic. It has already been stated that a woman in the 2nd stage of labour

experiences little, if any relief of pain from a low spinal anaesthetic. In any given individual the sum total of pain at any given stage of labour would appear to be fairly constant, and the relief of one area concerned accentuates the pain referred to others. The converse of this law is demonstrated by the relief afforded by the application of a mustard plaster in the treatment of localized pain.

I have many times succeeded in abolishing all pain, but if this is effected too early the patient goes out of labour. On only 2 occasions have I succeeded, by a combination of the local anaesthesia here described, together with blocking the pudendal nerves in the ischio-rectal fossa, in rendering both the 2nd stage of labour and delivery absolutely painless. This form of anaesthesia during childbirth probably has no wide application, but the most successful results are likely to follow blocking the first lumbar nerve as it emerges on either side, together with both pudendal nerves.

PART II

THE VISCERO-MOTOR REFLEX.

Mackenzie postulated that an irritable focus in the spinal cord, occasioned by afferent visceral stimuli, stimulated not only the sensory but also the motor nerves of the same segment. This he regarded as a protective mechanism. We may consider the implication of this hypothesis in relation to uterine pain. He assumed^{14, 15} that the stream of non-painful impulses travelling in the sympathetic pathways reaches "the pain scheme" (in the spinal cord) "at the synapses X, where the cerebrospinal and autonomic nerves meet." "The abnormal stimulus spreads beyond the sympathetic centre" (in the

posterior horn of the first lumbar segment) "and affects nerve cells in its immediate neighbourhood. The cells so stimulated react according to their function . . . the motor producing contraction of muscle." Now it is obvious that there are no motor cells in the posterior horn of the first lumbar segment, and it is a fact that contraction of the abdominal musculature is almost entirely affected by the lower intercostal nerves. We will however assume that Mackenzie had in mind a reflex effected by intercommunicating fibres in the cord for which experimental proof has been reported.

Miller and Simpson⁸ have caused contraction of the abdominal musculature, and movements of the hind legs in decapitated cats by centripetal stimulation of the mesenteric nerves, and also by traction on the stomach or its mesentery. McSwiney and Downman²⁹ have obtained similar results by pinching the duodenum or the head of the pancreas, and also by scraping or heating the serous coat of the gut. They found that the visceromotor responses sometimes deteriorated to extinction without noticeable change occurring in the general reflex activity of the limbs. Lewis and Kellgren³⁰ obtained the above responses by pinching the pancreas.

Lewis and Kellgren also caused palpable rigidity and deep tenderness of the lowest part of the abdominal wall, together with retraction of the testicle of the corresponding side in man, by injecting hypertonic saline solution into the first lumbar ligament. The significance of this experiment is lessened by the fact that the saline solution might have stimulated not only the somatic sensory, but also the relevant visceral-afferent nerves.

If now we turn to the clinical manifestations of the "visceromotor reflex" several observations may be made. In the first place this protective mechanism does not

always come into play. Secondly, it may be observed that the rigidity may either be generalized or strictly localized. The uterus, ovaries and Fallopian tubes are innervated by the first lumbar nerve. Unilateral salpingo-oophoritis is associated with muscle guarding of the lower abdomen limited to the same side, whereas toxæmic accidental hæmorrhage causes the most intense board-like rigidity of the whole abdomen, such as is seen in no other abdominal emergency. It is difficult to understand how a "commotion" in the first lumbar segment of the cord can determine which fibres of the abdominal musculature should contract to effect this varied and selective rigidity.

The most important observation of all is that, so far as I am aware, abdominal rigidity is nearly always, if not always associated with pain. It disappears under light anaesthesia, and is abolished by an injection of morphia. So far as is known light anaesthesia has no effect on the spinal cord. The action of morphia varies widely in different animals. In the dog and in man it depresses the pain apperception centre and stimulates the vomiting and salivary centres, but in therapeutic doses has no known effect on the spinal cord. The evidence with regard to the spinal cord is based on the response of somatic nerves, and the possibility cannot be excluded that morphia exerts a selective action, either on the visceral-afferent nerves themselves or on their synapses. The stream of impulses continues to reach the cord after the sensation of pain is abolished, and the rigidity should continue, unless it can be shown that both light anaesthesia and morphia do in fact exert a selective action either on the visceral-afferent nerves or on their synapses.

Kappis and Gerlach³¹ report that the abdominal rigidity associated with visceral disease may be abolished by the paraverte-

bral injection of a local anaesthetic. I²⁰ have instanced a still more striking phenomenon. The woman suffering from toxicæmic accidental hæmorrhage of the concealed variety is very ill and in great pain. The uterus remains in tonic contraction, and the abdomen exhibits a board-like rigidity. The foetal parts cannot be felt, and the foetus is invariably dead. In such a case I infiltrated the ilio-hypogastric and ilio-inguinal nerves with a 2 per cent solution of novocain, using 10 c.cm. on either side. The result was astonishing. All pain disappeared and the abdomen became soft, so that the foetal parts could be felt with ease, and the patient was able to lie on her back in comfort. Not long afterwards she delivered herself of a stillborn child. The placenta followed almost immediately afterwards, together with a mass of old retro-placental blood. It is impossible to reconcile this event with Mackenzie's visceromotor hypothesis, for anaesthetization of the skin of the lower abdomen could not²¹ conceivably affect an area of commotion in the spinal cord which is occasioned by a stream of impulses from the uterus.

A cord reflex, such as the knee jerk, either occurs in repetitive form or it does not occur, and there is neither analogy nor warrant for the assumption that such a reflex can be selective and so varied as to cause muscle-guarding limited to one side of the lower abdomen in some cases, and generalized abdominal rigidity in others. Neither is the knee-jerk nor the plantar response abolished by an injection of morphia.

It is not easy to cause abdominal rigidity limited to one side by an act of the will, neither can abdominal rigidity be voluntarily maintained. It is therefore reasonable to maintain that it represents the activity of a reflex, and evidence that such a reflex exists is afforded by experiments per-

formed on animals. The question at issue is whether it is, as is now generally accepted, a purely spinal reflex. It is possible that the reflex arc was in some manner broken by the paravertebral injections of Kappis and Gerlach. It might further be contended, although I think with considerable difficulty, that the subliminal impulses normally travelling in the relevant cutaneous sensory nerves are essential to the reflex.

It may therefore be concluded that abdominal rigidity rarely, if ever, occurs apart from pain, and is abolished by any procedure which abolishes the pain. This fact offers a strong argument in support of the view which I have advanced that the sensorium is involved in the "visceromotor reflex." This argument does not, however, amount to proof because it is possible that morphia, ether, and other general anaesthetics may exert a specific action on the visceral-afferent nerves or on their synapses in the cord. It is, however, of interest to note that McSwiney and Downman²² were impressed with the lack of correspondence between the general reflex activity of the hind limbs and the responses to visceral stimulation. They moreover found that transection of the spinal cord in the upper thoracic region markedly increased the motor responses to visceral stimulation in a decerebrate cat. This observation accords with, although it does not of necessity support the contention that central co-ordination is normally involved in the "visceromotor reflex."

SUMMARY.

1. Evidence is given which proves that the uterus, an abdominal viscus innervated by the sympathetic nervous system, is supplied by sensory nerves.

2. Uterine pain is a referred pain and there is no evidence of any deep, localized

uterine pain (the splanchnic pain of Ross). The quality of the pain is of the deep type.

3. Uterine pain is always referred to areas of skin supplied by branches of the 1st lumbar nerve, and can usually be abolished by anaesthetizing the cutaneous areas to which it is referred.

4. The pain arising from, or provoked in the uterus probably affords the most accurate delimitation of the 1st lumbar dermatome.

5. Uterine pain, in no way differing from that associated with dysmenorrhoea and labour, may be provoked in certain cases by applying a stick of silver nitrate to the cervical mucosa. It is probable that the endometrium is as, if not more sensitive than the cervical mucosa to this stimulus.

6. The most remarkable fact about this treatment with the silver stick is that it causes intolerable pain in some women and none in others. It is difficult to recall any other example in medicine where the same insult evokes such varied responses.

7. The cervix is not an inert structure, for the introduction of the silver stick frequently causes it to evince marked spasm. Pain is not usually experienced while the spasm lasts, but commences after the internal sphincter relaxes.

8. Tenderness to deep palpation over the tip of the transverse process of the 2nd lumbar vertebra, particularly on the left side, is almost invariably elicited in women who suffer from dysmenorrhoea. The dysmenorrhoea can often be "cured" for some months by one or more applications of the silver stick to the cervical mucosa.

9. Pain from the ovaries and fundus of the bladder is likewise referred to the lower abdomen, and to cutaneous areas supplied by the 1st lumbar nerve. The bladder

pain is localized to the centre of the lower abdomen, while ovarian pain is usually limited to the side of the offending ovary. Chronic ovarian pain may frequently be cured by treating the cervical mucosa with the silver stick.

10. Evidence is adduced to suggest that the so-called "viscero-motor reflex" involves central co-ordination.

11. The observations and experiments which have been recorded are opposed to the hypothesis advanced by Lennander and modified by Morley.

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*Investigation of the Serum Protein Balance in Normal and Toxaemic Pregnant Women

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WE all know that whenever a pathological process takes place in the animal organism it will always interfere more or less markedly with the protein balance of the organism. Under normal conditions this balance remains at a strikingly constant level. Also pregnancy, which cannot be regarded as a pathological process but which nevertheless strains the female organism very considerably, brings about marked shifts in the protein balance. It is therefore easily understood that the balance is shifted still further, if the pregnancy is complicated by pathological processes.

Surgeons and physicians have fully realized the great therapeutic importance of keeping not only the protein balance, but also the water and salt balances of the organism within normal limits. But obstetricians seem but slowly to become aware of the special field within the pathology of pregnancy and parturition, where

pronounced shifts occur in these 3 kinds of balance, and where further investigations might—as in surgery and internal medicine—be able to give fresh information on the origin of the disease and possibly lead the treatment on to new lines.

The disease considered here is the so-called toxaemia of pregnancy, a term which dates back several hundreds of years, but which is actually irrational. It is true that all the signs and symptoms, or at least most of them, can be produced if the pregnant woman is exposed to poisoning with some substance or other; but, despite intensive search, we have not so far succeeded in demonstrating any poison in the organism of the pregnant woman which might give rise to the disease. A great many theories have been advanced in the course of time concerning the genesis and mode of action of this hypothetical substance, but the origin of the disease is to-day precisely as mysterious as it was in the days of Hippocrates. When we continue to use the term "toxaemia of pregnancy" it is because we have not got a more adequate expression at present for the disease in question. (See however Thygesen and Møller-Christensen.)

The paper here presented deals mainly

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with our investigation of the protein shifts in serum. As, however, the protein balance and the water balance are interdependent to a very great extent, it is impossible to keep these two things apart. We shall therefore refer also to some of the results we found concerning changes in the fluid balance in the section where the results of the protein examinations are discussed.

INVESTIGATIONS.

The method of analysis applied by us for serum protein determinations and for fractioning of the proteins has been described by us elsewhere.² We therefore give no further account of it here, but refer the reader to Table I, which gives an idea of the accuracy of this method.

None of the results of analysis indicated in Table I occur in the remainder of our

the serum, for which reason the words albumin and globulin have been put in quotation marks.

Besides, by our own method all the sera have been examined by the method of total protein determination indicated by Bing.³ The results are given for each individual case in the following tables.

The blood tests were in all cases made in the morning after 12 hours of absolute fasting. The blood was taken from a vein in the arm during the shortest possible stasis. Immediately after the coagulation of the blood the serum was separated by centrifuging and placed in a refrigerator until the analysis could be made.

CASES UNDER REVIEW.

The persons examined can be divided into 3 groups: I, normal non-pregnant

TABLE I.

Total protein in serum, partly found, partly calculated as the sum of the found amounts of serum albumin and serum globulin.

Serum No.	"Albumin" found	"Globulin" found	Total protein		Difference	
			Calculated	Found	Absolute	%
	%	%	%	%	%	
1. Normal puerperium	6.25	1.10	7.35	7.30	0.05	0.7
2. Normal pregnant women ...	4.57	1.00	5.57	5.62	0.05	0.9
3. Toxaemic patient	5.51	1.32	6.83	6.72	0.11	1.6
4. Normal pregnant women ...	5.09	0.86	5.95	5.87	0.08	1.3
5. Normal pregnant women ...	5.56	0.83	6.39	6.44	0.05	0.8
6. Normal pregnant women ...	5.61	0.90	6.51	6.46	0.05	0.8
7. Normal non-pregnant women	5.85	1.09	6.94	6.97	0.03	0.4
8. Normal non-pregnant women	5.85	1.06	6.91	6.91	0.00	0.0
9. Toxaemic patient	4.12	0.75	4.87	4.98	0.11	2.2
10. Normal puerperium	5.60	1.77	7.37	7.37	0.00	0.0
Average	5.40	1.07	6.47	6.46	0.01	

work, because for practical reasons the sodium sulphate solution used for fractioning of the proteins was weaker in these control experiments than in the others. Thus the values found do not denote the actual amounts of albumin and globulin in

women; II, normal pregnant women; III, toxaemic pregnant women.

The normal and the toxaemic pregnant women were patients of the Rigshospital, Copenhagen, and the normal non-pregnant women were pupils of the school of

midwifery. The latter were given the same food as the normal pregnant women in order to avoid differences in protein values due to different standards of living. The toxæmic pregnant women were living on the diet always prescribed in cases of toxæmia, that is a "sick" diet poor in salt, 1,000 ml. of fluid per day, and, of course, the necessary addition of vitamins. This sick diet is not poor in proteins, and an extra amount of protein was often added. The normal pregnant women were not kept in bed.

7.16 per cent, namely serum albumin 4.67 per cent and serum globulin 2.49 per cent. The mean of the albumin/globulin quotient was 1.94.

A comparison with Bing's method shows that the two methods give fairly conformable results, both as regards the average values and as regards the minima and maxima.

GROUP II.

Group II comprised 20 normal pregnant women in the 2 last months of pregnancy (3 in their 9th month and 17 in their 10th

TABLE II.
Serum protein, per cent in 20 normal non-pregnant women.

Serum No.	Total protein %	Albumin %	Globulin %	Per cent protein as Albumin Globulin		Alb./Glob. quotient	Total protein A.M. Bing.
1.	7.58	4.92	2.66	65	35	1.86	6.9
2.	7.21	4.72	2.49	65	35	1.86	6.5
3.	6.56	4.78	1.78	73	27	2.70	6.5
4.	7.34	4.56	2.78	62	38	1.63	6.3
5.	7.87	5.34	2.53	68	32	2.13	7.4
6.	7.51	4.72	2.79	63	37	1.70	6.5
7.	6.67	4.32	2.35	65	35	1.86	7.1
8.	7.21	4.22	2.99	59	41	1.44	7.0
9.	7.64	3.66	3.98	48	52	0.92	6.9
10.	7.20	4.30	2.90	60	40	1.50	6.9
11.	7.42	5.16	2.26	70	30	2.33	7.0
12.	6.96	4.44	2.52	64	36	1.78	7.0
13.	7.18	4.80	2.38	67	33	2.03	7.1
14.	7.23	5.08	2.15	70	30	2.33	7.7
15.	7.24	5.25	1.99	73	27	2.70	7.5
16.	7.19	4.22	2.97	59	41	1.44	7.4
17.	6.10	4.81	1.29	79	21	3.76	6.2
18.	6.11	4.36	1.75	71	29	2.45	7.2
19.	7.01	4.60	2.41	66	34	1.94	6.9
20.	7.80	5.02	2.78	64	36	1.81	7.0
Average	7.16	4.67	2.49	66	34	1.94	6.95
Minimum	6.10	3.66	1.29	48	21	0.92	6.2
Maximum	7.87	5.34	3.98	79	52	3.76	7.7

GROUP I.

Group I comprised 20 normal non-pregnant women between the ages of 24 and 35. The results of the analyses have been entered in Table II, from which it appears that the average value of total protein was

month). In none of these cases did the urine contain protein or pathological cellular elements of any kind. The systolic blood-pressure did not exceed 125 mm. Hg. and there was no oedema. No more than during pregnancy did these women present

toxaemic signs and symptoms during parturition or the puerperium.

The results of the analyses appear in Table III, which indicates the following average values: total protein, 6.18 per cent; serum albumin, 3.75 per cent; serum globulin, 2.43 per cent; albumin/globulin quotient, 1.54.

While there was found a somewhat close accord between the results obtained by Bing's and our methods in the cases of non-

the total protein value to lie 1 g. per 100 ml. lower in the latter than in the former cases, namely 6.18 and 7.16 per cent respectively. This reduction in total protein seems to be due exclusively to a decrease in the amount of serum albumin, which was 3.75 per cent in normal pregnant women and 4.67 per cent in non-pregnant women. The amount of globulin was practically the same in both groups (2.43 per cent in the former and 2.49 per cent in the latter).

TABLE III.
Serum protein, per cent, in 20 normal pregnant women.

Serum No.	Month of preg.	Total protein %	Albumin %	Globulin %	Per cent protein as Alb. Glob.		Alb./Glob. quotient	Total protein A.M. Bing %
1.	10	5.96	4.05	1.91	68	32	2.12	5.0
2.	10	6.28	3.82	2.46	61	39	1.55	5.9
3.	10	6.16	3.88	2.28	63	37	1.70	6.0
4.	10	7.04	4.14	2.90	59	41	1.43	5.7
5.	10	6.68	4.05	2.63	61	39	1.54	5.8
6.	10	5.65	3.43	2.22	61	39	1.54	5.7
7.	10	6.51	3.95	2.56	61	39	1.54	5.8
8.	10	6.23	3.71	2.52	60	40	1.50	5.5
9.	10	6.30	3.88	2.42	62	38	1.63	5.5
10.	9	6.31	3.88	2.43	62	38	1.63	5.5
11.	10	6.04	3.39	2.65	56	44	1.27	5.9
12.	10	6.41	3.60	2.81	56	44	1.27	6.5
13.	10	5.73	3.63	2.10	63	37	1.70	6.0
14.	10	6.10	3.66	2.44	60	40	1.50	5.9
15.	10	5.99	3.77	2.22	63	37	1.70	6.0
16.	9	5.82	3.77	2.05	65	35	1.86	5.7
17.	10	5.57	3.61	1.96	65	35	1.86	5.5
18.	10	6.01	3.49	2.52	58	42	1.38	5.6
19.	10	6.45	3.78	2.67	59	41	1.44	5.5
20.	9	6.26	3.55	2.71	57	43	1.33	5.8
Average		6.18	3.75	2.43	61	39	1.54	5.72
Minimum		5.57	3.39	1.91	56	32	1.27	5.0
Maximum		7.04	4.14	2.91	68	44	2.12	6.5

pregnant women, there proved to be some difference as regards the normal pregnant women, in so far as the values were found to be 5 to 10 per cent lower when calculated by Bing's method than when calculated by ours.

A comparison between the average values of normal non-pregnant women and normal pregnant women (Table IV) shows

In other words the balance of the serum protein fractions proved to have shifted towards the globulins—the coarsely disperse phase of the proteins—a fact which manifested itself by a change in the albumin/globulin quotient amounting to 1.94 in the non-pregnant women and 1.54 in the normal pregnant women.

Expressed as percentages the shift means

a fall in the amount of albumin from 66 per cent in non-pregnant women to 61 per cent in normal pregnant women, and a rise in the amount of serum globulin from 34 per cent in the former to 39 per cent in the latter.

Mild cases: No, or but moderately, visible oedema. Systolic blood-pressure not exceeding 150 to 160 mm. Hg. Albuminuria not over 3 or 4 per mille (Esbach) in 24 hours' urine. No, or but moderate, headache. Occasionally slight visual dis-

TABLE IV.

Average values of results of protein analyses in non-pregnant and normal pregnant women, in cases of mild and severe toxæmia, and in eclampsia patients.

	Serum protein analyses, a.m.				
	Bing	Th. and M.-C.			
	Total protein %	Total protein %	Albumin %	Globulin %	Alb./Glob. quotient
Non-pregnant women ...	7.0	7.16	4.67	2.49	1.94
Normal pregnant women ...	5.7	6.18	3.75	2.43	1.54
Mild toxæmia ...	5.3	5.95	3.26	2.69	1.21
Severe toxæmia ...	5.0	5.40	2.91	2.49	1.17
Mild and severe toxæmia ...	5.1	5.63	3.06	2.57	1.19
Eclampsia ...	5.1	5.56	3.27	2.29	1.43

GROUP III.

The third group comprised 24 toxæmic pregnant women, namely 10 cases without eclampsia and 5 cases with eclampsia.

The cases without eclampsia were again divided into 2 sub-groups: 8 mild cases of toxæmia and 11 severe cases.

Such a division, which is made on the basis of the clinical signs, presents numerous difficulties. First, it depends to a great extent on the observer's judgment; secondly, we cannot actually pronounce with full certainty on the degree of the complaint until after delivery and the puerperium; and finally we have experienced cases which were at first characterized as being of a mild or fairly mild degree, but which in the course of a short time (perhaps only a few hours) developed into severe toxicoses, sometimes even developing eclampsia.

Our division in mild and severe cases was based on the following facts.

turbances, but absolutely no retinal changes.

Severe cases: Generally pronounced oedema (face, hands and abdomen). Systolic blood-pressure exceeding 150 to 160 mm. Hg. Albuminuria generally over 3 or 4 per mille (Esbach) in 24 hours' urine, often a great deal more. Often severe headache. Often visual disturbances with retinal changes.

On this basis we divided, as mentioned above, the 19 cases of toxæmia without eclampsia into 8 mild and 11 severe cases.

In none of these cases (nor in any of those with eclampsia) was the pregnancy preceded by renal disease or hypertonia which might be thought to have been the cause of, or to have aggravated, the toxæmic condition.

The results of our investigations will appear from the following tables, where, besides the results of Bing's and our methods of analysis, we have added data which give an impression of the clinical

TABLE V.
Serum protein analyses of 8 patients suffering from mild toxæmia.

Protein analysis made number of hours before parturition				Serum protein analyses, a.m.						Clinical signs and symptoms at time of protein analysis					Information on parturition		Course of previous pregnancies and parturitions						
No.	Age	Para	120	Thygesen and Møller-Christensen					Bing	Total protein, %	Albumin, %	Globulin, %	Alb./Glob. quotient	Blood-pressure mm. Hg.	Oedema	Albuminuria o/oo Esbach		Headache	Eye signs and symptoms	Course	Fœtus	Placenta	
				5.1	5.45	2.98	2.47	1.21															
1	23	1	120	5.1	5.45	2.98	2.47	1.21						160/110	+	2.0	0	0	0	Forceps	Alive 3050 g. 50 cm.	1 White infarct	1st and 2nd preg. and part. normal
2	32	3	72	5.8	6.35	3.92	2.43	1.63						125/75	+	0.5	0	0	0	Normal	Dead 950 g. 39 cm. mac.	0	
3	23	3	72	5.7	6.36	2.92	3.44	0.85						125/75	0	1.5	0	0	0	Normal	Alive 2250 g. 43 cm.	2 White infarcts	1st and 2nd preg. and part. normal
4	41	6	24	5.6	7.03	3.96	3.07	1.29						155/100	0	0.4	+	Flickering ophthalm. nothing abnormal	Normal	Dead 2800 g. 50 cm. mac.	Abruptio placenta. præmat.	4 first preg. and part. normal 5th part.: eclamp.	
5	22	1	24	4.8	4.92	3.31	1.61	2.03						130/80	+	0.4	0	0	0	A: Norm. B: Norm.	Alive 2000/45 Alive 1850/45		0	Eclampsia during 1st part.
6	23	2	15	5.2	5.89	3.21	2.68	1.22						135/80	0	0.4	0	0	0	Normal	Alive 2000 g. 49 cm.	0	
7	17	1	68	5.1	6.09	3.19	2.90	1.10						145/65	+	1.1	0	0	0	Normal	Alive 2850 g. 48 cm.	0	
8	27	1	132	5.1	5.51	2.62	2.89	0.91						140/80	+	3.8	0	0	0	Normal	Dead 1400 g. 41 cm. mac.	Abruptio placenta. præmat.	

Average	5.3	5.95	3.26	2.69	1.21
Minimum	4.8	4.92	2.62	1.61	0.85
Maximum	5.8	7.03	3.96	3.44	2.03

TABLE VI.
Serum protein analyses of 11 patients suffering from severe toxæmia.
analysis a.m.

[illegible]

state of the patient on the day the blood test was made. In addition the tables give information on each patient's age, parity, the course of labour and the condition of the placenta, and on the course of previous pregnancies and labours.

Table V illustrates the results of our examinations of 8 pregnant women suffering from a mild toxæmia. The average values as well as the maximum and minimum values have been entered at the foot of the table.

Table VI gives a corresponding survey of the results concerning the 11 cases of severe toxæmia.

A comparison between the average values from the 2 latter tables is seen in Table VII, lines 1 and 2.

Although we should, of course, be careful in drawing conclusions from such comparatively small numbers of cases, it is nevertheless a remarkable finding that the amount of total protein was smaller in the

1.17 in the severe cases and 1.21 in the mild cases.

The average values for all the 19 cases have been entered in Table VII, line 3. (It is, however, doubtful whether such a joining of mild and severe cases is at all justifiable; but that is a problem to which we hope to return on a later occasion). By comparing these values with those calculated for normal pregnant women (line 4) we found out that the patients suffering from toxæmia without eclampsia presented an unquestionable reduction in the total protein of the serum. This reduction seems to have been due exclusively to a decrease in the amount of albumin, since the amount of serum globulin had not decreased in these patients; on the contrary it had, if anything, increased.

The results of the examinations of the 5 eclamptic patients are shown in Table VIII. The eclampsia was mild in all 5 cases, each patient having had only one

TABLE VII.

Average value of results of protein analyses in mild and severe cases of toxæmia, as well as for all cases of toxæmia collectively.

				Serum protein analyses, a.m.				
				Bing	Thygesen and Møller-Christensen			
				Total protein %	Total protein %	Albumin %	Globulin %	Alb./Glob. quotient
Mild toxæmia	...	...	...	5.3	5.95	3.26	2.69	1.21
Severe toxæmia	...	...	...	5.0	5.40	2.91	2.49	1.17
All cases of toxæmia without attendant eclampsia	...	...	...	5.1	5.63	3.06	2.57	1.19
Average values for normal pregnant women	...	...	...	5.7	6.18	3.75	2.43	1.54

severe cases than in the mild ones, namely 5.40 and 5.95 per cent respectively. The fractioning shows that albumin and globulin contributed equally to the reduction, since the albumin/globulin quotient was practically the same in the 2 groups, that is,

fit. In 4 cases the fit occurred before parturition and in 1 case after.

Of course we cannot draw any definite conclusions from this very small number of patients; but a comparison between the average values for eclamptic patients and

TABLE VIII.
Serum protein analyses of 5 patients suffering from Eclampsia.

[illegible]

those for the other toxæmic patients suggests the following conclusions (compare Table IV, lines 5 and 6).

The amount of total serum protein proved to have become reduced to an equal extent in the toxæmic patients presenting eclampsia and those not presenting eclampsia. While the reduction was due exclusively to a decrease in the amount of serum albumin in the cases of the non-eclamptic patients, the eclamptic patients were found—compared with the normal pregnant women—to present a decrease both in serum albumin and in serum globulin.

For the sake of completeness we should mention the treatment to which our 5 eclamptic patients were submitted. Number 1 was given morphine and chloral hydrate according to Stroganoff's scheme. Number 2 was given morphine according to Stroganoff's scheme, 100 ml. of a 50 per cent glucose intravenously, 2 g. chloral hydrate 5 hours after the fit, and finally a total of 4 Percorten injections of 5 mg. each* in the course of the first 12 hours after the fit. Number 3 was given morphine and chloral hydrate according to Stroganoff's scheme. Number 4 was given Percorten only, 15 mg. in the course of 3 hours after the attack. Number 5, who was transferred to our department from a clinic in Copenhagen after she had had a typical eclamptic fit, was treated exclusively with Percorten (a total of 115 mg.). The patient was not given any morphine whatever, and she was delivered of a child in the normal way without narcosis a week after her admission after a medical induction of labour.

Finally, as regards Bing's test, it appeared that in the cases of the toxæmic pregnant women, as in those of the normal

pregnant women, the values found were from 5 to 10 per cent lower than those obtained by our method (compare Table IV). The content of lipoid in the serum of pregnant women is probably the cause of the difference in the results.

DISCUSSION.

In comparing our results with those published in previous papers we have found it expedient to treat each of the following groups separately: I. Normal non-pregnant women. II. Normal pregnant women. III. Pregnant women suffering from toxæmia without eclampsia. IV. Pregnant women suffering from toxæmia with eclampsia.

I. Normal Non-pregnant Women.

Table IX gives a survey of the average values which the various investigators indicate as normal for healthy non-pregnant women.

The last line of the table indicates our calculations of the average values for all authors collectively. We arrived at the following results. Total protein 7.30 per cent; serum albumin, 4.65 per cent; serum globulin, 2.65 per cent; albumin/globulin quotient, 1.75.

It appears from the table that the values accord fairly closely with each other. The differences found are due in the first instance to different methods of analysis. The investigators who used the gravimetric method (Siedentopf,⁴ Albers⁵) and the refractometer method (Eufinger and Spiegler^{6, 6a}) found the highest values, particularly as regards the serum albumin.

The results of the investigators who used Kjeldahl's method, or modifications of that method (Dienst,⁷ Eastmann,⁸ Adair,⁹ Møller-Christensen and Thygesen²) do not differ very much from each other. Exceptions are Zangemeister¹² (Kjeldahl),

* We thank the Ciba Farver & Farmaceutica Ltd., for having placed Percorten Ciba (desoxycorticosteronacetate) at our disposal.

fairly closely to those obtained by Kjeldahl's method.

II. Normal Pregnant Women (last stage of pregnancy.)

It appears from Table X that, in the case of normal pregnant women, the various writers give proportional amounts of the different serum proteins which are fairly alike, with a single exception only.

latter half of pregnancy than in non-pregnant women. This reduction is due chiefly to a decrease in the amount of serum albumin (about 13 per cent), whereas the percentage decrease in serum globulin is smaller (about 7 per cent).

The table shows Eufinger and Spiegler's results to differ a great deal from those arrived at by other writers. This is par-

TABLE XI.

Comparison between the investigations made by the various writers of the serum proteins in toxæmic pregnant women not presenting eclampsia.

Writer, year, method of analysis, number of cases				Total protein %	Serum albumin %	Serum globulin %	Alb./Glob. quotient	
Dienst (1918)	Kjeldahl's method	6 cases		4.63	3.31	1.32	2.51	
Zängemeister (1919)	Kjeldahl's method { Mild cases Severe cases	26	„	6.44				
		25	„	6.04				
Bergmann (1924)	Refractom. method			6.3				
Eufinger and Spiegler (1928)	Refractom. method			6.44	1.62	4.82	0.34	
Eastmann (1931)	Hove's method	6	„ Severe cases	5.4	3.1	2.3	1.3	
(Siedentopf (1938)	Gravimetric method (incl. eclampsia)	16	„	6.13	3.54	2.59	1.40)	
Albers (1939)	Gravimetric method	8	„ Severe cases	5.45	2.63	2.83	0.93	
Neuweiler (1940)	Henriques and Klausen's method	24	„	5.15	2.56	2.59	0.99	
Adair (1940)				6.0				
Dexter and Weiss (1941)			Severe cases	5.54	3.06	2.46	1.26	
Dieckmann and Kramer (1941)			Severe cases	6.34	3.24	3.10	1.05	
Møller-Christensen	{ Bing's method Th. and M.-C's method	8	„ Mild cases	5.3				
and Thygesen			11	„ Severe cases	5.0			
(1945)			8	„ Mild cases	5.95	3.26	2.69	1.21
			11	„ Severe cases	5.40	2.91	2.49	1.17
Average values of the above results (Except those of Eufinger and Spiegler and Siedentopf)				5.64	3.01	2.63	1.14	

The differences are also here due chiefly to the application of different methods of analysis. They may probably also be due to the fact that the patients were not all of them in the same month of pregnancy when the analyses were undertaken. Finally we cannot leave out of account the possibility that different social environments may have played a part.

Common to all the analyses is the fact that the total protein value is lower in the

ticularly the case with regard to the determinations of fractioning. For this reason Eufinger and Spiegler's results were not included in our calculation of the average values for all writers, which calculation presents the following percentages (compare the last line of the table).

Total protein, 6.35 per cent; serum albumin, 3.88 per cent; serum globulin, 2.47 per cent, albumin/globulin quotient 1.57.

decrease in serum albumin alone that brought about the reduction in total protein.

Some investigations of the amount of blood in normal pregnant women have been published within recent years (Albers⁵). The various investigators all arrived at the result that an increase in the blood volume of between 10 and 20 per cent takes place within the last few months of pregnancy. Simultaneously the amount

min, probably owing to a loss of albumin through the kidneys. The amount of serum globulin is slightly greater if anything than that found in normal pregnant women.

As mentioned before, it is hardly correct to collect all cases of toxæmia without eclampsia in one group. Table IV shows that the severe cases presented lower values of both serum albumin and serum globulin than the mild cases. That the amount of

TABLE XIII.

	Total protein %	Serum albumin %	Serum globulin %	Alb./Glob. quotient	Haematocrit Vol. %
Normal non-pregnant women	7.30 (7.16)	4.65 (4.67)	2.65 (2.49)	1.75 (1.94)	(39)
Normal pregnant women (Final stage of pregnancy)	6.35 (6.18)	3.88 (3.75)	2.47 (2.43)	1.57 (1.54)	(34)
Toxaemia patients not presenting eclampsia ...	5.64 (5.63)	3.01 (3.06)	2.63 (2.57)	1.14 (1.19)	(34)
Toxaemia patients presenting eclampsia	5.61 (5.56)	2.94 (3.27)	2.67 (2.29)	1.10 (1.43)	(39)

of albumin decreases in the same proportion, as appears from our investigations, whereas the amount of serum globulin is fairly unchanged.

We must conclude from these observations that the circulating amount of serum albumin is the same within the last few months of pregnancy as it is in the non-pregnant women, whereas the amount of circulating serum globulin is essentially greater in the pregnant woman than in the non-pregnant woman.

It appears further from Table XIII that the haematocrit value is the same in toxæmic patients without eclampsia as in the normal pregnant women, whereas the amount of total protein is decreased. The fractioning shows that this reduction is due exclusively to a decrease in the amount of serum albu-

serum albumin was smallest in the severe cases is easily explainable by the fact that these patients lost more albumin through the kidneys than those suffering from mild toxæmia. We shall return later to the causes of the low globulin values. The 2 groups also presented a difference, although, indeed, a small one, in haematocrit values, in so far as the haematocrit was 33 volumes per cent in the mild cases and 35 volumes per cent in the severe ones, that is, the latter group showed a tendency to haemoconcentration.

As regards the eclamptic patients our results do not accord with those of previous writers. We found a decrease in serum globulin and a corresponding increase in serum albumin, whereas others generally found an increase in serum globulin.

It appears from the last column of Table XIII that the haematocrit value is the same in eclamptic patients and in non-pregnant women. This means that haemoconcentration has occurred and that the blood volume has become smaller in these patients than in normal pregnant women and in patients suffering from toxæmia without eclampsia. When this reduction in the blood volume is taken into consideration the conclusion is very naturally drawn that it is not only the amount of circulating albumin that is decreased in the cases of patients suffering from eclampsia, but that there occurs also a decrease in the amount of circulating serum globulin.

There are two possible explanations of the decrease in serum globulin. One is that globulin may be supposed to be lost through the kidneys or the endothelium of the capillaries. But if this should be the case the simultaneously occurring loss of albumin should be far greater than it actually is. The other, and in our opinion more likely explanation is that, if eclampsia is present, the power of the organism of producing serum globulin has somehow or other been diminished.

We believe that most investigators are inclined to think that the reduced amount of globulin is due to an impaired liver function. Attention should in our opinion be given also to the adrenal cortex. It is a well known fact that the hormones of the adrenal cortex are of great importance for the water balance, and very probably have a rather considerable influence on the production of serum globulin as well. The more one considers the problem of toxæmia of pregnancy the more often one meets with facts which seem to be traceable to the adrenal cortex. And, without wanting to prophesy, we would not be surprised if (in a short time) it became possible to find in the adrenal cortex the solution to the

mystery of both toxæmia of pregnancy and eclampsia.

CONCLUSION.

(1) The following average values for serum protein have been found by a method of analysis developed by the authors.

(a) In normal non-pregnant women (20 cases): total protein, 7.16 per cent; serum albumin, 4.67 per cent; serum globulin, 2.49 per cent.

(b) In normal pregnant women within the 2 last months of pregnancy (20 cases): total protein, 6.18 per cent; serum albumin, 3.75 per cent; serum globulin, 2.43 per cent.

(c) In patients suffering from mild toxæmia without eclampsia (8 cases): total protein, 5.95 per cent; serum albumin, 3.26 per cent; serum globulin, 2.69 per cent.

(d) In patients suffering from severe toxæmia without eclampsia (11 cases): total protein, 5.40 per cent; serum albumin, 2.91 per cent; serum globulin, 2.49 per cent.

(e) In patients suffering from toxæmia with eclampsia (5 cases): total protein, 5.56 per cent; serum albumin, 3.27 per cent; serum globulin, 2.29 per cent.

(2) Taking into consideration the changes in the blood volume we concluded that in the cases with eclampsia the amount of serum globulin circulating in the blood seems to be reduced. Previously the general opinion was that the amount of serum globulin was increased.

(3) The causes of the changes in the protein balance are discussed, and attention is directed to the adrenal cortex, which probably plays a greater part in toxæmia of pregnancy and eclampsia than is generally supposed.

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Six Cases of Venous Intravasation following Intrauterine Lipiodol Injection

BY

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THE intrauterine injection of radio-opaque oils, such as lipiodol, is now such a common method of investigation of uterine abnormalities, and especially of tubal patency in cases of subfertility, that I have thought it of interest to put on record 6 cases of venous intravasation following this operation.

In Cases 1, 3, 4, 5 and 6 I carried out the investigation personally and these occurred after a series of some 200 to 300 cases of salpingography without mishap. Case 2 was operated on by a house officer at another hospital.

The conditions predisposing to this accident are said to be the following:

1. Injection of lipiodol before full post-menstrual regeneration of the uterine mucosa, that is, within a period of less than 8 days after the termination of menstruation;
2. Injection immediately after dilatation of the cervix;
3. Injection after curettage, before a proper interval has elapsed to allow of regeneration of the mucosa;
4. Injection just prior to the onset of menstruation, when the congested and oedematous mucosa readily allows of traumatization;
5. Injection with excessive force.

Other predisposing factors are said, by Rohan Williams,¹ to be retrodisplacement or lateral displacement of the uterus with possible impinging of the oil-bearing cannula against the uterine wall. In my opinion this should not happen if a careful

bimanual examination be done beforehand to determine the exact position of the fundus, if this be confirmed by the gentle passage of a uterine sound, and if the curve of the oilbearing cannula corresponds to that of the uterus. Examining the 6 reported cases we can see if and where the above rules were neglected.

CASE 1. Mrs. W. I carried out salpingography in December 1942, and both Fallopian tubes were found to be patent. Pregnancy followed almost immediately but unfortunately ended in miscarriage in the 3rd month, and the patient failed to conceive again. At her request salpingography was repeated in September 1945, when, owing to a misunderstanding, the operation was carried out just after the end of a monthly period (see contra-indication 1). Fig. 1 shows the right Fallopian tube to be freely patent, and the left possibly blocked at the cornua. There is intravasation of dye to the pelvic veins. The patient did not show any ill effect at the time although an X-ray of the lungs showed fine flecks of scattered lipiodol. After returning home, however, she experienced prolonged irregular vaginal loss, followed by a heavy "period," suggesting a mild pelvic inflammatory condition. Such a consequence was also reported by Flew² whose patient developed a left hemiplegia and a slight haemoptysis. Later, Mrs. W. became pregnant.

CASE 2. Mrs. B. The operation here was carried out by a house surgeon at an unfavourable time in the month, 4 to 5 days before the expected onset of the period. It is possible, also, that excessive pressure may have been used (contra-indications 4 and 5). The degree of intravasation of the pelvic veins is remarkable (Fig. 2). Haemoptysis or other ill effect did not follow. X-ray of the lungs was

not carried out for 2 or 3 weeks and, as will be seen later, a report of clear lung fields in this case at this date is not of great value.

Cases 3, 4 and 5. There next follow 3 cases which were all carried out within a week or two of each other, and which were the first examples of this complication that I had met. In all these cases the conditions for safety were fulfilled, and the only unusual common factor I was able to trace was a new and rather rough-surfaced rubber covering to the oilbearing cannula, this having presumably traumatized the cervix and permitted the ingress of lipiodol to the pelvic veins.

CASE 3. Mrs. F. Operation January 13th, 1944; last monthly period December 27th, 1943. The Fallopian tubes were patent to air and lipiodol was injected, intravasating the pelvic veins (Fig. 3).

The possible complications were not realized at the time and the patient was allowed to go home next day. She was re-admitted about a week later with a history of slight haemoptysis and soreness on the right side of the chest. X-ray of the chest taken on January 22nd, 1944, shows "a very fine, faint stippling giving a granular appearance through both lungs; ? lipiodol in minute quantities in the terminal capillaries." Slight haemoptysis continued for a few days without rise in pulse or temperature, and the patient was able to leave hospital within a week. X-ray of the chest taken on March 16th, 1946, reports "the lungs are now perfectly normal in appearance" (Fig. 7).

CASE 4. Mrs. C. Salpingogram, February 1st, 1944; last monthly period January 16th, 1944. X-ray report after injection of lipiodol—left Fallopian tube patent; right doubtful; intravasation of lipiodol to uterine venous plexus (Fig. 4). Three days later the patient had slight haemoptysis, and X-ray of the chest showed an appearance similar to Case 3 (Fig. 5). This case and the next were examined by a consulting physician who reported that no abnormal physical signs in the chest were present in either patient, but suggested that the X-ray appearances were due to minute pulmonary infarcts following a mild thrombophlebitis produced by some toxic principle in the lipiodol. X-ray of

the chest repeated in this case on February 21st, 1944, showed excellent illumination without any trace of lipiodol (Fig. 6).

CASE 5. Mrs. S. Salpingogram, February 1st, 1944; last monthly period January 20th, 1944. X-ray shows intravasation of uterine venous plexus; both Fallopian tubes blocked at fimbrial ends. X-ray of chest as in Cases 3 and 4; haemoptysis 3 days later. End result good.

CASE 6. Salpingogram, July 24th, 1945; last monthly period July 10th, 1945. All conditions for safety appeared to be fulfilled in this case, but X-rays showed both tubes patent and venous intravasation to both iliac veins (Fig. 7). Subsequent history and X-ray findings as in previous cases.

Notes have been given of 6 patients in whom salpingography by means of the intrauterine injection of lipiodol was followed by pelvic venous intravasation. Sequelae have been noted and an attempt made to determine why these accidents took place.

COMMENTARY.

Robins and Shapiro, quoted by Rohan Williams¹ have reviewed a series of 1,000 salpingographies. Intravasation to the pelvic veins occurred in 18 cases without recognizable complications. Walther, quoted by Williams, on the other hand, reported pain in the chest, cough and blood-stained sputum as a manifestation of pulmonary oil-embolism, and 1 death from this complication. When this complication does occur, few if any consequences ensue, but some have been dangerous and some fatal.

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FIG. 1.

12.9.1945. Right tube freshly patent; left tube ? blocked at cornua.
Intravasation of dye.

A.B.



FIG. 2.

Lipiodol in all the pelvic veins, and extending up the ovarian veins out of the picture.

A.B.



FIG. 3.

Hystero-gram. Large quantity of lipiodol present, and the appearance is very suggestive of intravasation to venous channels.

A.B.



FIG. 4.

Left tube patent. Right tube doubtful. Some intravasation of oil to uterine venous plexus.

A.B.



FIG. 5.

Case 4. 14.2.1944. Appearances suggest minute pulmonary infarcts.
A.B.

Spinal Analgesia for Forceps Delivery in Abnormal Labour

BY

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I.

THERE can be no doubt that forceps delivery after prolonged labour, be the abnormality in the powers or in the passages or in both, may be a major operation, and as such demands an anaesthetic that will not be a contributory factor in the production of shock. Yet how often is this realized and skilled anaesthesia sought? I believe that so much attention has been paid to anaesthesia for Caesarean section on the one hand, and to the relief of labour pains on the other, that anaesthesia for forceps delivery has received far too little attention either in textbook or clinical teaching. The result of this neglect has been the administration of too many unskilled, prolonged, general anaesthetics in difficult deliveries. The anaesthetic itself is a factor to which, in the past, insufficient attention has been paid when death followed delivery; and, in the absence of severe haemorrhage or traumatic delivery, the (probably non-existent) condition of "obstetric shock" has often been diagnosed. Having seen such tragedies and many more near-tragedies, in which the maternal condition after delivery was worse than before, out of all proportion to the difficulty of the delivery, I am convinced that general inhalational anaesthesia (most usually nitrous oxide, oxygen and ether) must be responsible for many avoidable fatalities and much prolonged invalidism.

It may be claimed that this state of

affairs calls only for more skilled anaesthetists, and to a certain extent this cannot be denied. At the same time it cannot be too strongly emphasized that anaesthesia for delivery, where two lives are at stake, is a special problem, and this fact is not always appreciated even by anaesthetists. The picture of a patient delivered under pudendal nerve block by a low forceps operation, even after prolonged labour, is in such contrast to the condition of those above referred to that it seems that a higher nerve block, such as is afforded by low spinal analgesia, must be the solution for difficult cases. Accordingly, a deliberate trial of spinal analgesia has been undertaken. The results were revealing and the fear that the anaesthetic would prove to be the last straw has been entirely banished. The description of cases in which spinal analgesia was used will, I hope, help to break down some of the prejudice against it, and also help towards the recognition, not only of its safety, but of its superiority to other anaesthetics for the mother, child and obstetrician. I have also included cases of eclampsia and the "failed forceps" case.

Caesarean sections were not included in this trial (although the prejudice against spinal analgesia is largely against its use in sections) as other factors are then involved; moreover the ideal anaesthetic for sections, local infiltration combined if necessary with pentothal, has few, if any, contra-indications. However, as most of the arguments in this controversial subject

involve Caesarean section, it must be referred to.

II.

An account of the opinions found in the more authoritative obstetric and anaesthetic textbooks is given here, as it illustrates the general confusion that surrounds this subject.

Beck,¹ for instance, mentions spinal analgesia only for labour pains and not for operative deliveries at all. Curtis,² operating in Cosgrove's unit, was forced to admit that the relaxation was all he could ask for, but states: "However, the danger of this method is ever present, and I very rarely use it." As a concession he describes a case in which it would be suitable "... that of prolonged second stage with a respiratory complication, provided the patient presents a completely dilated and effaced cervix." This sentence alone confirms his rare use of the method.

De Lee³ held spinal anaesthesia to be very dangerous in obstetric practice, but admitted that the reasons were not all known. To quote his summing-up: "Anyway, why should we run any risks at all when we can do Caesarean sections just as well, and infinitely more safely, with local infiltration, and can do vaginal deliveries likewise under antesacral, or pudendal nerve block, or infiltration of the tissues." While I agree entirely in leaving out inhalation anaesthesia, I am partial to pudendal nerve block for low-cavity forceps operations, and believe that spinal block has a definite place in more difficult deliveries. Skill can be acquired in its use, and one must remember what Wevill has emphasized, namely, that the anaesthetist's task is not over once the drug has been injected into the theca; constant supervision is as necessary as with general anaesthetic.

Munro Kerr⁴ states that spinal block is "most useful in cases of operative interference where a general anaesthetic is contra-indicated." Here speaks experience, though it is hardly informative. Stander⁵ condemns spinal analgesia for operative deliveries in general because of a number of unrecorded instances of death on the operating table during the performance of Caesarean section; but no information is offered as to the possible causes of these tragedies. Before this condemnation, however, it is stated that operations of any kind can be performed with the greatest ease.

From the anaesthetist's viewpoint, Minnitt and Gillies⁶ devote only a dozen lines to anaesthesia for major obstetrical operations other than Caesarean section; but they do emphasize that the shock "of procedures such as prolonged forceps delivery . . . is considerable." While recommending various inhalational agents they apparently forget their earlier statement that "no general anaesthetic, however, can provide absolute protection against shock-producing stimuli in the same way that nerve block does, unless all tissues of the body are saturated by the drug to a degree approaching overdosage." They mention that "there is much evidence that pregnant women are particularly sensitive to spinal anaesthesia"; and, although they offer no explanation of this supposed sensitivity, they do indicate the obvious explanation when they state that "more tragedies could be avoided if it were realized that the operation of Caesarean section could usually be performed under an amount of anaesthetic which need be little greater than half the dose required for abdominal gynaecological operations." They might have added that with low spinal block, sufficient for vaginal deliveries, tragedies can all be avoided.

Wevill, in the book by Minnitt and Gillies, when discussing rachi-resistance,

mentions that "rachi-sensitivity is supposed to occur in certain toxæmias . . . and pregnancy," but that the theory of rachi-resistance "has not found general acceptance and it would certainly be most unwise to fall back on rachi-resistance to explain failures, without first of all scrutinizing most carefully the technique." Surely the time is long overdue when the same criticism should be applied to rachi-sensitivity and the above-mentioned particular sensitivity of pregnant women.

Langton Hewer⁷ only refers to spinal block for deliveries by abdominal section, and states that "operative deliveries can be done under pure nitrous oxide-oxygen anaesthesia from the beginning. The addition of ether is rarely necessary." However, he states, too, that reflex shock can be minimized by deep general anaesthesia, and practically prevented by suitable nerve blocking.

Marshall,⁸ in his monograph on lower segment Caesarean section, discusses fully the employment of ether, local and spinal analgesia. His case against ether is to my mind unanswerable: it increases atony, haemorrhage, acidosis, post-operative vomiting and ileus. Ether has, too, toxic effects on the liver and kidneys, lowers the peritoneal resistance to infection, and is a common cause of foetal asphyxia. Marshall quotes Schulcz as saying that "deaths after Caesarean section are either due to infection or anaesthesia," and believes this deserves a high place among obstetrical aphorisms. Of the advantages of spinal anaesthesia, Marshall mentions diminished haemorrhage and immediate closure of the uterine sinuses leading to a lower incidence of morbidity, absence of effect on metabolism, liver and kidneys, and a dynamic effect on the intestinal tract; consequently vomiting, atony and ileus are much less common in the puerperium. Finally the foetus is quite unaffected and is born as

fresh as in a spontaneous birth. Much of what Marshall writes is applicable to vaginal deliveries in prolonged labour.

Under the heading "The peculiar susceptibility to spinal anaesthesia of women undergoing Caesarean section" Marshall examines the case against this agent. But as from this heading many controversial points arise, it will be studied more thoroughly in the discussion. The views of 3 experienced protagonists remain to be given—Maxson,⁹ from the anaesthetist's viewpoint, Cosgrove¹⁰ and Delmas¹¹ from the obstetrician's. Of spinal block in obstetrics, Maxson says that "it has never obtained recognition as a fully accepted method. Yet those who have used it intelligently are enthusiastic in its praise." He writes from personal experience of its use in Caesarean section; but for vaginal deliveries he falls back on Cosgrove's published views, because he has had "no experience in the field."

Cosgrove's experience is second to none in the use of spinal block for delivery, and his work should be studied by all who wish to try the method. It suffices here to say that he mentions all the advantages already listed by Marshall above, and adds those of absolute muscular relaxation, perfect analgesia, and the immediate post-operative ability to ingest food and fluid; also, less laceration due to greater relaxation, which itself leads to less morbidity and less shock. His account of the dangers included no mysterious unspecified factor peculiar to pregnancy.

Delmas concentrated on the condition of the cervix under spinal block and the opportunity afforded of manually dilating the cervix rapidly. Bittman¹² confirmed the use of Delmas's method in eclampsia "when rapid evacuation is called for," and he regarded the fall in blood-pressure as therapeutic. Modern obstetric practice is against rapid evacuation in eclampsia ex-

cept by section (itself a highly controversial procedure) and this has helped to put Delmas's views into a fog of disrepute. Summarizing trials of his method by other workers, Delmas complains of the general lack of understanding and of criticism without experience that still exists about spinal anaesthesia in obstetrics. His method is the digital dilatation of the cervix under spinal block "in cases in which failure to interfere was unjustifiable, and in which the artificial emptying of the uterus seemed to be necessary or at least desirable." He also stated that "clinical observations have shown that in spite of its effect in lowering blood-pressure, the procedure is quite safe." Delmas used it in only 4 per cent of his total deliveries.

Anaesthesia for difficult forceps operations emerges from this brief summary as the Cinderella of obstetric anaesthesia. In Caesarean section either one perfects one's own technique of local infiltration, or engages the help of an expert anaesthetist if the case is a serious one; while in simple low-forceps delivery a patient can stand up to a short inhalational anaesthesia if she has been in labour only for a normal time. Alternatively she can be delivered under pudendal nerve block if labour has been prolonged.

The value of the following series of cases does not lie of necessity in its numbers, but in the fact that they were all selected difficult cases, in which blood-pressure readings were taken throughout the duration of the operation. Further, in each case the spinal anaesthetic was given and the delivery conducted by the same individual—myself. As space would not allow a summary of every case with blood-pressure readings, Table I has been prepared, showing, it is hoped, as many as possible of the details that obstetricians would wish to know before they were satisfied that the alleged difficulties did really exist.

In 25 cases operative delivery was necessary through inability on the mother's part to deliver herself owing to malposition of the foetus, disproportion, inertia and to prolongation of labour, with various combinations of these factors. One case had no obstetric difficulty, but had collapsed under chloroform outside hospital just before delivery was attempted. Twenty-two were primigravidae, with an average age of 31 years, 11 being over 33 years of age. The average weight of the infants was just under 8 pounds, 16 being over 8 pounds. The most important indication, however, was the association of inertia and the resultant prolongation of labour. Seventeen of the 25 had primary inertia, 14 of sufficient degree to present the "full blown" picture with distension of bladder and colon—the most difficult type of obstetric case and one carrying a grave risk of postoperative shock.

The average duration of labour was just over 60 hours, in 7 cases being over 90 hours. This alone, I believe, should serve as a *contra-indication* to inhalational anaesthesia as commonly administered. Of the 14 cases of severe primary inertia, 3 infants died, 1 before delivery was undertaken, and 2 after—a mortality of 21 per cent compared with Bourne and Bell's 40 per cent, and in none of these could the anaesthetic be held responsible.

The duration in hospital for 23 patients, 2 being transferred to the City Fever Hospital on the 2nd day after delivery, was an average of 17.4 days.

Two mothers died; 1 from pulmonary embolus on the 17th day of the puerperium, and the second from streptococcal septicaemia contracted before admission. This case actually survived 9 days, probably because of the atraumatic delivery under spinal anaesthesia.

Tables II and III give details of 6 cases in which forceps delivery had failed outside

Days in hospital	Dose of procaine in mg.	Blood-pressure before spinal, and lowest systolic level reached (mm. of Hg.)	Remarks
17	120	140 to 100	
22	120	135 to 105	
2	130	140 to 90	To fever hosp. Died 9th day of Group 'A' haemolytic streptococcal septicaemia
16	150	120 to 100	Died: Pulmonary embolism 16th day
16	150	110 to 60	Corrected by Trendelenburg position
13	150	120 to 60	No distress. Corrected spontaneously
9	75	145 to 115	
13	100	165 to 100	
10	120	130 to 100	Foetal head too high for delivery
—	(i) 130	190 to 70	N.N. death from Bact. coli. meningitis
24	(ii) 100	130 to 100	on 4th day
21	100	120 to 60	Trendelenburg correction Morbidity/mastitis
16	50	130 to 110	
29	110	150 to 95	Foetal heart 170/min. Died of pneumonia
42	120	120 to 70	Foetus died during labour
16	80	130 to 105	
16	75	160 to 120	Rotation to OA, after 44 hours under N ₂ O, O ₂ , + ether
33	100	165 to 150	Trial labour: Toxaemia at 36 weeks
10	100	180 to 130	
16	80	140 to 110	Not collapsed on admission
13	100	130 to 75	Intracranial haemorrhage, SB
14	120	124 to 80	To fever hospital. Recovered
2	75	145 to 128	Kielland's forceps, no distress
12	80	120 no change	Kielland's forceps, no distress
11	100	145 to 110	Kielland's forceps, no distress
11	75	130 no change	

Reason for outside failure	Remarks
Non-recognition of deep transverse arrest	SB through impaction of shoulders
" " "	Forceps marks on face from outside attempt
Cervix not fully dilated	—
Non-recognition of deep transverse arrest	—
Presenting part too high	No distress. Methedrine restored to 110/70 in 5 minutes
Non-recognition of deep transverse arrest	—

Blood-pressure before spinal, and lowest systolic level reached (mm. of Hg.)	Remarks
150 to 90	Slept during delivery
180 unchanged	Mastitis
150 to 130	—
165 to 110	Slept during delivery

hospital—another strong indication for avoiding further inhalational anaesthesia; and of 4 cases of eclampsia delivered under spinal block, none of the mothers and only 1 infant was lost.

The question of morbidity, having as it does a hard and fast definition, is also illustrated in Tables I and II in 2 different columns, the one showing morbidity by definition, and the other those cases which had a pelvic infection, irrespective of whether or not the temperature rose high enough to fulfil the definition. Unfortunately it is impossible to show a comparable series of cases delivered under general anaesthesia (as all my cases were specially chosen), but Bourne and Bell's morbidity-rate in inertia was 40 per cent. Of the 31 patients in Tables I and II, 14 developed a pelvic infection (45 per cent) but only 7 (22.5 per cent) were severe enough to be morbid. The 14 true inertia-syndrome patients, with an average of 66 hours in labour, included 7 (50 per cent) who developed pelvic infection, of whom only 3 (21 per cent) were morbid. Some of the credit for keeping this figure down must of necessity go to the sulphonamides, but many of the infections were due to anaerobic streptococci which do not respond to these drugs. In passing, it may be remarked that after spinal anaesthesia the ingestion of sulphonamide drugs is much more likely to be rapidly efficient than during the usual postoperative condition following inhalational anaesthesia.

Neither figures nor statistics can describe the well-being of women delivered under spinal block; their condition is entirely different to that commonly observed when prolonged labour is terminated under general anaesthesia. In many instances improvement is immediately manifested; in all cases, after a sleep for which every labouring woman yearns, they are fully able to take nourishment and regain strength rapidly, a factor of untold

importance in keeping down the expectedly high morbidity.

BLOOD-PRESSURE CHANGES.

Hewer disapproves of taking frequent blood-pressure readings, as he contends that it disturbs a conscious patient and might cause sore arms, but Maxson advises any beginner in spinal analgesia to take frequent readings "as the only means of learning the full effect of the dose given." Wevill regards such recordings as of little value and thinks they may distract the anaesthetist's attention from other signs of far greater importance. Maxson's advice was, however, faithfully followed by me not only as a means of becoming acquainted with the effects of different dosages, but also to add the great benefit of the reassurance thus provided. I did not come across sore arms; and as for disturbing consciousness, a woman in labour for a long period, even if she be highly strung and nervous, is in a state highly receptive to explanation of how her pain will cease. Many, contentedly finding the prophesy come true, drop off to sleep in spite of delivery and recordings of blood-pressure.

The guidance obtained by the records of blood-pressure was certainly of the greatest value, for a few patients had a fall in systolic level which in the presence of surgical shock or haemorrhage would have necessitated instant treatment, yet in none of these was there at any time signs of shock or distress. Further the pulse-pressure was always at least 20 mm. Hg.

At the end of the first 3 tables the initial blood-pressure and the level to which it fell is given, in order to correlate the dose and its effect on each patient. But in considering the fall in blood-pressure it must be remembered that this normally rises during labour, and that when the pain of uterine contraction is removed a certain degree of fall must be attributable to that alone, a fall

that must vary according to each patient's constitutional make-up and her threshold to pain. This is borne out by Hewer's observations on spinal block in patients with other causes of acute abdominal pain. In many cases, therefore, a mere recording of the actual fall in pressure may be totally misleading, that from 180 mm. to 100 mm. Hg. being of very different significance to a drop of 120 mm. to 40 mm. Both aspects of the pressure-drop are illustrated in Tables IV and V—the actual drop and the lowest

whom the systolic dropped to 60 mm. Hg. none showed any distress, respiratory, circulatory or mental.

As the trial proceeded, smaller doses were found to produce perfect conditions for delivery. Eventually (in some simple cases not here recorded) it was found that 50 mg. of procaine could be given by so slow an injection as to produce analgesia only of the perineum and vagina, and physical distress was caused by attempting the abdominal manipulation of the shoulder in

TABLE IV.
Average Drop of Blood-pressure in Millimetres of Hg., Correlated with Dose of Procaine.

Mg. procaine	Actual drops recorded (mm./Hg.)	Average drop (mm./Hg.)
150	20, 50, 60	43
130	50, 120	85
120	40, 30, 30, 50, 45, 60, 55	44
110	55	55
100	65, 30, 60, 15, 50, 55, 35, 20, 60, 26	42
90	0, 55	27
80	25, 30, 0, 45, 0	20
75	30, 40, 15, 0, 40	25
50	20	20

TABLE V.
Average Lowest Systolic Recording, Correlated with Dose of Procaine.

Mg. procaine	Lowest systolic level recorded (mm./Hg.)	Average (mm./Hg.)
150	100, 60, 60	73
130	90, 70	80
120	100, 105, 100, 70, 80, 90, 55	91
110	95	95
100	100, 100, 60, 150, 130, 75, 110, 84, 120, 90	105
90	180, 110	145
80	105, 110, 120, 140, 130	120
75	115, 120, 128, 130, 120	123
50	110	110

systolic level reached in relation to the dosage of procaine used. It will be seen, in spite of misleading factors, that the larger the dose is the larger the drop—the site of injection being the same. This is, of course, well recognized; but it is not fully appreciated that women in labour do not show any peculiar deviation from this general rule, and that even in those patients in

rotating a posterior occiput—in such a case there would be no drop in blood-pressure beyond that due to removal of pain. The final dosage employed was 50–75 mg. of procaine for lower deliveries and 75–100 mg. for higher.

Table VI, showing details of 6 cases in which the blood-pressure was known before labour, illustrates the rise due to labour.

One patient was a known hypertensive and appears in Table I (No. 10): 2 spinal anaesthetics were given to this patient within 14 hours, for on the first occasion it

spinal needle was inserted with the bevel turned to the side (so as to split the thecal coverings rather than tear them), and cerebrospinal fluid to the extent of 3 c.c. (about

TABLE VI.

Six Cases in which Antenatal Blood-pressure was known before Labour.

	Blood-pressure before labour	Immediately before delivery	Mg. procaine	Lowest blood-pressure recorded
1.	120/75	140/90	100	130/85
2.	120/80	125/95	100	105/60
3.	135/85	180/95	100	130/90
4.	130/80	165/110	100	150/100
5.	150/80	190/85	130	70/48
6.	130/85	165/95	100	100/80

was found that the presenting part was too high to attempt delivery.

In only 1 patient of the 36 detailed was the pulse-rate quicker after delivery than before, in most it was decidedly slower. The 1 case was due to severe bleeding from an episiotomy wound.

The size of the infant was found to have no influence on the ultimate lowest systolic pressure which, as has been already stated, fluctuated only according to the level of anaesthesia.

TECHNIQUE.

All injections were made into the 4th lumbar interspace. For the first few cases the lateral position was used, but it was soon found that the patient was better able to keep still in the sitting position, and, I believe, was more comfortable. As it undoubtedly made for an easier tapping, and better control of the level of anaesthesia, the sitting position was adopted early and was thereafter adhered to.

Full aseptic and antiseptic precautions and a virtual no-touch technique was used in inserting the needle. Iodine was preferred as a skin antiseptic and the proposed puncture-site wiped dry of iodine before an intradermal wheal was raised with 1 per cent procaine. A small-bore (22 gauge)

55 drops) was collected into the ampoule of 150 mg. of procaine crystals, thus forming a 5 per cent solution. The solution was drawn into the syringe which was attached to the spinal needle, which was then turned so that the bevel pointed downwards before the necessary quantity was injected. The dose given was on the estimated difficulty of delivery. Barbotage was never practised.

Even in obese patients little difficulty should be experienced in tapping the theca, provided one has an eye for the midline and can palpate the iliac crests.

As procaine takes effect in 3 or 4 minutes and is fixed in 5, the patient was kept sitting for this period, and her pains had ceased by the time she had been arranged in the lithotomy position with one pillow under her head. Sleep was more probable when omnopon had been given just before delivery, but, as this tended to cloud the issue it was given only in the first few cases. The giving of ephedrine intramuscularly half-an-hour prior to operation was also abandoned when it was found to be irregular in its action, not preventing some of the greatest falls in blood-pressure. Instead, a close watch was kept for visible signs of collapse—pallor, cold clammy skin, and (most reliable of all according to Maxson)

a feeling of respiratory oppression. None of these signs was seen. By the time methedrine hydrochloride was reported on by Dodds, I had little need for its aid, though it was used in a few cases in which everything claimed for it was fully confirmed. As for side effects, only 3 patients vomited and not one complained of headache, in spite of the fact that no special instructions were given as to raising the foot of the bed, et cetera, after the return to the lying-in ward. Most patients naturally lay flat, sleeping, and were allowed to move as they liked when they awoke. No single cause apparently accounts for post-spinal tap headaches, but the majority of opinions favour the theory of leakage of cerebrospinal fluid leading to diminished intracranial pressure. Cosgrove's patients ceased to be troubled by headaches as soon as he used a small-bore needle. Lundy¹³ believes the headaches to be attributable to disturbances of intracranial pressure and that "excessive attempts to puncture the dura and arachnoid, even without injection of a spinal anaesthetic agent, may result in headache, backache, and leucocytosis, but not usually in fever. These symptoms probably are attributable to meningeal irritation secondary to trauma and sub-arachnoid bleeding." Beattie and Dickson¹⁴ mention small holes found in the theca. Short of careless technique leading to a true meningitis, I feel the single "tap", splitting the thecal fibres, with no more than a few seconds disturbance of cerebrospinal fluid pressure by using it as a solvent and replacing it, reduces the problem of headache to insignificance. Only one other possibility remains—some unexplained chemical irritation by the anaesthetic agent itself, and from this point of view procaine is generally regarded as the least toxic of all such agents. Burton,¹⁵ in a recent series of cases complicated by cardiac disease and delivered under heavy nupercaine,

was troubled by post-spinal anaesthetic headaches lasting up to a week. There is, however, in such cases, no need to use a heavy anaesthetic agent, for as good results can be obtained with procaine into the 4th interspace.

DISCUSSION.

Although the results of any method are usually the best arguments "for and against" (and I hope it will be conceded that there is little fault to find with the results now presented), the subject of spinal analgesia for delivery is so controversial that a more detailed discussion is called for.

What is the nature of the usually undefined dangers of spinal analgesia for delivery? Cosgrove¹⁶ mentions 3—vasomotor, circulatory, and respiratory paralysis, and to these must be added the possibility of some direct toxic action from absorption into the circulation of the anaesthetic agent. Rachi-sensitivity has already been commented on.

With analgesia reaching to the umbilicus, representing a spinal level of the 10th dorsal segment, the three dangers mentioned by Cosgrove are entirely avoidable. Too high an ascent of anaesthetic solution may, however, result "in lowering of blood-pressure to the point where the heart fails to get the needed nutrition" (Maxson) with resultant cerebral anoxia of the vital centres, and to progressive upward paralysis of respiratory mechanism—the intercostal muscles, the diaphragm and the medulla. But it is important to understand that this respiratory paralysis, with the exception of the intercostal paralysis, arises from cerebral anoxia through low blood-pressure, and not from direct action of anaesthetic solution. Blomfield¹⁷ supports this view and states "that with novocain and allied drugs there is no fear of

paralysing the respiratory centre even if the injected dose travels up in the cerebrospinal fluid. This does not apply to Stovain. Novocain is now being used fearlessly for operations above the umbilicus, indeed by some for operations in any part whatever."

Regarding vasomotor collapse, it cannot reasonably be held that blocking of only 5 sets of autonomic nerves (D.10 to L.2) will produce sufficient collapse to lead to a condition irreversible by the simple employment of the Trendelenburg position or the injection of methedrine.

Circulatory collapse, the third of Cosgrove's suggested dangers, is evidenced by fall in blood-pressure, and I believe, with the technique already described, that this fall is completely controllable and, if necessary, reversible. Maxson quotes Porter and Smith¹⁸ as follows: "The criterion is not the absolute or percentile fall of blood-pressure *per se*, but whether there remains sufficient blood-pressure to carry on for a time at least the work of nerve cells in the brain and cord . . . the danger line may probably be placed at 60 mm. Hg." Maxson adds: "the young and robust will withstand a fall to 30 mm.; the aged and infirm are seriously embarrassed by a drop to 50 mm." Waldron¹⁹ emphasizes that the important safeguard is the pulse pressure, and that as long as this stays above 20 mm. Hg. one should not be too much concerned about a pressure drop, "particularly if it is symptomless." Cosgrove stated that he had no cause to be concerned over excessive blood-pressure drop in a series of over 500 cases of all kinds; his patients had their blood-pressures recorded throughout, and he found an average systolic fall of 23 mm. Hg. for a 50 mg. dose and 38 mm. Hg. for a 75 mg. dose. Referring to these dosages, Maxson states that "low spinal anaesthesia is safe without exception" and, as Cosgrove, and Minnitt and Gillies point

out, they are about half that which is usually used.

The disasters which have undoubtedly occurred are usually, as De Lee said, unrecorded and it is highly probable that the blood-pressure at the time was also unrecorded.

"The danger of spinal injection (Blomfield) is . . . if by any chance the dose used is excessive there is no means of extracting any part of it. In the course of many hundreds of injections there occurs, sooner or later, an unexpected collapse. This is probably to be attributed to the power which injected analgesics have of lowering blood-pressure." Minnitt and Gillies also include, under the acute circulatory failure known as neurogenic shock, the type of circulatory disturbance caused by factors which influence the nervous system directly, such as trauma or spinal analgesia. These opinions are quoted simply to emphasize that such disasters as have occurred have, in all probability, been due to overdosage, to poor observation of the patient's condition after the anaesthetic solution was injected, or to employment of drugs not so safe as procaine.

The final danger to be discussed is the possibility of toxic absorption of procaine from the spinal theca, and this is inextricably bound up with the question whether pregnancy carries with it some mysterious or, as Marshall puts it, "peculiar susceptibility." I believe that in Marshall's complete heading, "The peculiar susceptibility to spinal anaesthesia of women undergoing Caesarean section" lies the probable truth, for he offers four possible explanations, of which only one has anything to do with Caesarean section, and the rest refer to susceptibility arising from the state of pregnancy. Once more we find confusion—this time the confusion as to whether it is the pregnancy or the Caesarean section that is dangerous from the point of view

of spinal analgesia. I believe it is the latter, and that Marshall's words were well chosen, implying as they do that the susceptibility arises out of the mechanism of the operation. Many obstetricians and anaesthetists believe that there is something mysterious about pregnancy that makes spinal analgesia dangerous, but Macintosh and Mushin²⁰ state that "on commonsense grounds it appears to us to be a bogey to suggest that pregnancy makes a woman peculiarly susceptible to the effects of spinal analgesia." Hewer, however, writes that "the mortality of Caesarean section under spinal block is for some reason high, and the method is not to be recommended." No more, no less, and we get no further forward.

Marshall suggests that there is a lowered capillary permeability in pregnancy favouring entry into the circulation of the anaesthetic agent. That this cannot have any real significance is proved by the fact that he eventually chose as the safest method local infiltration of the abdominal wall. Now 150 to 200 c.c. of $\frac{1}{2}$ per cent procaine is commonly used for this method (and many operators are not afraid of greater quantities and higher concentrations); but this is a dose of 750 to 1,000 mg. injected into a much more vascular tissue than the enclosed space of the theca, where there are nerves with a recognized affinity for procaine, which "fixes" in 5 minutes. Moreover procaine may be given therapeutically intravenously (Lundy) in cases of cyclopropane epinephrine tachycardia.

Secondly, Marshall suggests that there may be some connection between the existing lipidaemia and "increased toxicity of spinal anaesthesia during pregnancy." But he gives no clue as how the lipidaemia is dangerous, even if it were admitted that there was a dangerous absorption of procaine from the theca, and

I can find no warning in the literature against spinal analgesia in any other condition with increased lipidaemia. Here again, local infiltration of large amounts as now widely practised would inevitably have led to innumerable disasters if there were any danger of this kind.

Thirdly, Marshall suggests an increased shift of blood volume into the splanchnic area and lower limbs leading to anoxia of vital centres. This is not peculiar to pregnancy as far as it is caused by vasomotor paralysis, and it is corrected simply by the Trendelenburg position. But if he includes the sudden release of pressure during the delivery of the child then, I think, he is getting at the root of the matter, for all anaesthetists are wary of spinal analgesia for any condition involving sudden lowering of intra-abdominal pressure, such as large retroperitoneal or ovarian cysts, and even in simple paracentesis for ascites it is traditional to prepare "brandy and a binder" in case of collapse. There is here a definite possible cause of collapse in Caesarean section, where there has already occurred the normal average blood-pressure drop due to the spinal block. If the collapse occurs before delivery it is much more likely to be due to overdosage and careless technique than to any mysterious susceptibility peculiar to pregnancy.

Marshall's fourth possible cause of such susceptibility is that labour pains and bearing-down efforts lead to more rapid diffusion of the anaesthetic agent in the spinal canal. De Lee also believed that during labour the fluid in the lower cord canal was "pressed up towards the medulla, causing respiratory paralysis." That this latter mechanism does not occur with procaine has already been pointed out, and I find it hard to believe that with 2 ml. (the maximum dose of an agent that is fixed in 5 minutes), the uterine pains and bearing down can be of any danger whatsoever.

quite apart from the fact that the level of analgesia reached was never noticed to be higher in patients who were still having strong pains. Few of my cases were having strong pains, and fewer still showed any uncontrollable bearing-down efforts.

To sum up this question, I feel that the conclusion is inescapable that the effect of spinal block with procaine depends on nothing more than the level of analgesia reached, and that the so-called "peculiar susceptibility of pregnant women" to spinal nerve block has no foundation in fact, beyond the possibility of collapse due to the comparatively rapid decrease of intra-abdominal pressure in Caesarean section. It is, as Minnitt and Gillies wisely remark, "the natural instinct of anyone, who has suffered the misery and ignominy of causing a death under an anaesthetic, to attribute it to some condition beyond human control." I cannot believe that it is beyond control, and Thomas's²¹ series of Caesarean sections under heavy nupercaine is added proof that a technique, learnt with the aid of the sphygmomanometer, leads to smaller dosage and complete safety.

SURGICAL SHOCK.

Most writers now recognize the necessity of describing shock by an epithet indicating its cause. Before going further it must be stated that collapse due to spinal analgesia is not included as its aetiology is clear, and the essential difference, as Hewer says, is that there is no change in the volume of circulating blood. Maxson also remarks that slowing of the heart concurrent with lowering of blood-pressure constitutes an essential difference between the hypotension of spinal anaesthesia and that of shock. For the slower rate gives the heart muscle longer rest periods and, when accelerator impulses

return, it is in good condition—quite the opposite from the vicious circle of surgical shock. Analgesia to the umbilical level has no effect on accelerator impulses, and in my cases the pulse-rate usually fell through removal of pain and substitution of rest.

How, then, may surgical shock arise during vaginal operative deliveries? Its initiation is probably determined by one or more of the following: (1) Haemorrhage from the uterus or lacerated tissues in the canal below; (2) plasma loss into traumatized pelvic tissues; (3) neurogenic factor, viz, repeated, powerful, sensory stimuli; (4) production and entry into the circulation of histamine-like substance as the result of trauma; (5) toxic effects of anaesthetic drugs; (6) psychogenic influences. I do not believe that "obstetric shock", in the shape of yet another mysterious factor peculiar to pregnant women, exists. All cases of shock following delivery are capable of explanation by one or more of the factors above mentioned and the term "obstetric shock," arising as it does from the desire to attribute disaster to some condition beyond human control should be rigorously excluded—it is, in fact, merely an "escape" diagnosis.

It will be agreed that the majority of my cases were strong candidates for secondary shock, yet not one suffered from it, and I submit that this is largely because the delivery was carried out under spinal block. It is generally conceded that haemorrhage from the uterus is less, and haemorrhage and plasma loss from tissue damage is also minimized because of the perfect relaxation of the passages obtained, an effect which also lessens the production of histamine-like substances. Reflex or neurogenic shock, from intra-pelvic manipulation, pulling and stretching, etc., is naturally completely prevented by nerve block.

Minnitt and Gillies depict a graph of the blood-pressure during a hernia operation under open ether in which the blood-pressure fell to 70 systolic and 65 diastolic following mobilization of the testis and handling of intestine. General anaesthesia cannot prevent this type of shock. Hewer states the modern view that there is a definite inhibition of the vasomotor centre by afferent nociceptive stimuli, and that this type of shock can be minimized by *deep* (my italics) general anaesthesia, and practically prevented by suitable nerve blocking. "There has recently been a tendency to discount the effects of stimuli during light anaesthesia" and Hewer believes that the reaction has gone too far. I support Minnitt and Gillies in their view that deep anaesthesia can only inhibit such harmful stimuli by overdosage, and such overdosage itself leads to shock in the very attempt to prevent it. Nash epitomizes this aspect in stating that "very prolonged administration of a general anaesthetic can, and does, lead to the development of real surgical shock. The condition thus produced may be considered anaesthetic shock in the true sense and is quite distinct from the immediate and specific toxic effects of the drug. It is surgical shock whose chief predisposing cause is anaesthesia." Psychogenic shock may be looked on as a branch of neurogenic shock and, as I have already mentioned, I did not find any fear, even in nervous patients, provided time was taken to explain just what was going to happen.

It is contended, therefore, that, except for psychogenic shock, of which there is no more danger than in general anaesthesia, spinal analgesia is of supreme value in preventing surgical shock in difficult deliveries after prolonged labour. It is noteworthy that Bonney²² always used spinal block to minimize shock in his Wertheim hysterectomies.

OPERATIVE CONDITIONS.

The advantage of spinal block in ensuring complete relaxation is too well known to need repetition here, but certain other points should be mentioned: Firstly, with regard to dilatation of the cervix, I have no doubt that Delmas's practice of digital dilatation would be as easy as he asserts; for often I found, in spite of the primary vaginal examination suggesting full dilatation, that a centimetre or so of dilatation had yet to occur. In such cases the relaxation of the cervix enabled an easier and less traumatic completion of dilatation than under general anaesthesia. Occasionally manual rotation of the occiput was unexpectedly found to be necessary and distress was caused by abdominal pressure above the level of analgesia—a very small amount of pentothal remedied this. As uterine irritability is not affected the tendency that some patients have to form a contraction ring, as when the occiput is rotated, may dictate delivery face to pubes, as in Case 2. This was, however, the only time that this particular abnormality occurred. Several rotations were performed with Kielland's forceps applied by his method and only once was distress produced, and this during the application of the posterior blade as it reached the promontory of the sacrum. The dose in this case had been underestimated.

Occasionally the presenting part was low enough to deliver with episiotomy, and at this level spinal block has no great advantage over pudendal nerve block, provided the occiput does not need a difficult rotation; but when the presenting part was at mid-cavity level, or just above, in primigravidae, episiotomy was preferred to ironing out the vagina.

In grossly infected cases in which the operator envisages the use of sulphonamide powder on lacerated or incised tissues, spinal analgesia should be employed rather

than local or pudendal nerve block, for procaine inhibits the action of sulphonamides.

A further advantage of spinal block lies in the greatly diminished risk of vomiting and cyanosis, such as is not infrequently seen during the induction of inhalational anaesthesia at the end of prolonged labour—as a result the delivery is conducted in a quiet and peaceful atmosphere and post-partum aspiration pneumonia and pulmonary collapse are almost completely avoided.

THE THIRD STAGE.

Placental dystocia and haemorrhage from uterine atony was unknown in my cases, though in 5 the placenta was removed manually immediately after delivery as a deliberate policy. This practice arose out of the necessity, sometimes occurring after delivery under general anaesthesia, of having to give a second anaesthetic to remove a retained or partially adherent placenta, though latterly pentothal was used for this second anaesthetic. In spinal block deliveries immediate manual removal was given up, and pentothal was not required as the natural process always occurred.

INDICATIONS AND CONTRA-INDICATIONS.

Details of 3 types of case have already been given, but it is felt that attention should be paid particularly to the inertia syndrome (Goodall²³) and dystrophica dystocia of De Lee, as indications *par excellence* for spinal analgesia. Williams's²⁴ description of the latter cannot be bettered: the distressing labour for days, exhaustion, the membranes long ruptured, signs of intrapartum infection and foetal distress, the cervix not fully dilated, the head high and the occiput probably lateral or posterior, "we are then dealing with one of the most serious types of case in obstetric practice." Goodall completes the picture of the depleted, infected mother, usually

badly injured during instrumental delivery, with vomiting, dehydration, acidosis, intestinal and vesical obstinacy, use of the catheter, cystitis and sub-involution due to infection and inertia.

Three of the cases in Table I were judged to be true cases of dystrophica dystocia, while many others had more than half of the usual features. It was in such cases that De Lee considered Caesarean section would have been a better choice at the outset, and Williams agreed. Yet it is precisely in this type of case that one carries out expectant treatment the next time after consideration and decision upon vaginal delivery. I would only urge that obstetricians, thus having burnt their boats, will find all the advantages of spinal analgesia come to their aid when the moment for delivery arrives. Many of the terrors that follow prolonged deep general anaesthesia are in this manner banished. Goodall admitted, in drawing attention to the inertia syndrome, that he had nothing new to suggest in its treatment; it is a pity that the fact that general anaesthesia may well be the last straw is not more widely recognized. For cases which have already had inhalational anaesthesia for attempted delivery, or for early rotation of an occipito-posterior position, there can be little question that a second such anaesthetic should be avoided at all costs.

In eclampsia and non-convulsive toxæmia spinal block for delivery is equally beneficial, and Cosgrove here emphasized its use as there is no effect on the liver or kidneys, and by lowering the blood-pressure and slowing the heart the myocardium is relieved. There is no deleterious action on the respiratory tract, and the central nervous system is protected from noxious shock influences by complete blocking of peripheral neurons; further it does not cause cyanosis and has no deleterious effect on the child. Hewer regards

high blood-pressure as a contra-indication only if accompanied by marked arteriosclerosis, and he agrees that the method had been used with success in eclampsia.

In cardiac cases, Burton's series is sufficient indication of safety, though it is known that cardiac patients often escape difficult deliveries, and most can be delivered under local infiltration and pudendal nerve block.

I would go so far as to say that the only contra-indication—apart from skin sepsis and spinal deformity—is severe shock and hypotension, and that once these are corrected (as they should be prior to operative interference) spinal block will not only cause no further deterioration of the general condition but will help to prevent it.

THE CHILD.

I do not think that any of the critics of spinal analgesia will deny the great advantage to the child. Sturrock points out that anoxaemia, due to over-dosage with analgesics or to development of cyanosis during general anaesthesia, is a preventable cause of foetal death, and that gas and oxygen "is much more difficult to administer successfully in pregnancy and labour than in general surgical cases if cyanosis is to be avoided." He also reminds us of Schreiber's pioneer work in tracing cerebral lesions in later life (spasticity, convulsions and mental retardation) to anoxaemia during delivery.

The benefit to the child is especially noticeable in prolonged labours and in trial labours. How often do we see a trial labour successful mechanically, the disproportion at the pelvic brim surmounted at the expense of the mother's strength, and the foetus still to be subjected to a mid-cavity forceps operation under general anaesthesia, an agent which may be the last straw to the child even more often than to

the mother? Although spinal block relaxation cannot directly prevent either intracranial damage or foetal infection, it provides the easiest conditions for delivery, and by leaving the child free of any narcotic influences it is in better condition to ward off infection.

Finally, many obstetricians now agree that asphyxia from morphine is often really due to the superadded effect of a general anaesthetic, and, as Cosgrove points out, spinal analgesia obviates this well-recognized synergism. But, though well recognized, it is not sufficiently emphasized in current teaching, for the simple reason that general anaesthesia being customary it is easier to teach the traditional avoidance of morphine during the 4 hours before delivery, and to omit mention of the dangers of the combination of morphine and general anaesthesia.

SUMMARY.

1. A series of deliveries under spinal analgesia in difficult obstetric cases is presented.
2. As a result of this experience and a search in the relevant literature, it is concluded that low spinal analgesia for difficult forceps delivery carries no danger peculiar to the pregnant woman, and that the disasters that have occurred are capable of a perfectly rational explanation and are not due to any mysterious susceptibility.
3. That as well as being a safe procedure it is maintained that spinal analgesia is of paramount importance in preventing secondary shock and minimizing haemorrhage and morbidity, and that it also prevents further deterioration in an already depleted patient.
4. Frequency of failure to recognize prolonged general anaesthesia as an important contributory factor in the production of shock is stressed, and an exhortation is

made to eschew the term "obstetric shock" as being an escape diagnosis.

5. The benefit to the child, particularly in prolonged and trial labours, is emphasized, especially as spinal analgesia avoids the combination of morphine narcosis with superimposed general inhalational anaesthesia.

I wish to express my gratitude to Professor R. W. Johnstone for permission to use patients under his care, and to Drs. E. Chalmers Fahmy and John Gillies for much encouragement and help. Also I wish to thank the many house surgeons who recorded the blood-pressure for me, and Sister Anderson of the Simpson Maternity Pavilion, who always had my "spinal packet" ready for instant use.

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Calcium and Phosphorus Metabolism in Pregnancy (A Survey under War and Post-war Conditions)

FIRST COMMUNICATION ON THE CALCIFEROL FACTOR.

BY

E. OBERMER, M.D., M.R.C.S., L.R.C.P.

In a previous communication¹ the general scope of this investigation has been outlined. The calcium intake and output figures for a group of control women and a group of women fed a supplement of calcium phosphate were given. The calcium and phosphorus balances were analysed. No correlation could be found in either of these 2 groups between the various factors usually considered to influence calcium metabolism, such as Ca:P ratio of the diet, protein or fat intake, potential acid-base balance of the food, et cetera. The figures, however, seemed to demonstrate that the probability of a positive calcium balance throughout pregnancy became greater above a certain level calcium intake.

In the present communication, a further 14 cases* are dealt with, covering 67 48-hour balance periods at 6 weekly intervals from the 2nd or 3rd month of pregnancy to term. The calcium intake, output and balance figures for these further 14 cases are given in Table I. These figures, together with the figures given in the previous communication¹ are further discussed, splitting them into 3 groups in the following manner:

Group I. Controls, that is, no mineral

or vitamin supplement, but on a self chosen diet with the optional addition of the statutory daily pint of milk. The figures for Cases 1 to 12 (controls throughout the period of observation) and the initial findings of Cases 13 to 22, before the supplementary feeding with calcium phosphate was started, have been given in the previous communication.¹

In the present communication the figures given in the first part of Table I—from Cases 24 to 36 before supplementary calcium phosphate and vitamin D feeding was commenced—have also been treated as controls.

Group II. Cases on a self chosen diet, together with the following supplementary doses of calcium phosphate (the figures represent amounts of calcium and phosphorus elements per 24 hours).

	Calcium	Phosphorus
3rd to 5th months	0.64 g.	0.282 g.
6th to 8th months	0.95 g.	0.423 g.
8th month to term	1.26 g.	0.564 g.

Figures for Cases 13 to 22 were given in the previous communication,¹ and the figures for Case 23 are given, herewith, at the top of Table I.

Group III. Cases investigated in the same conditions as Group II cases, that is, on a self chosen diet with identical calcium phosphate supplements to Group II, and in addition a supplement of calciferol in the following doses.

* Case 23 (aged 26) had a normal previous pregnancy in April 1944. Cases 24 (aged 34), 25 (aged 29), 26 (aged 24), 28 (aged 33), 28 (aged 31), 29 (aged 33), 30 (aged 29), 31 (aged 35), 32 (aged 32), 33 (aged 34), 34 (aged 31), 35 (aged 25) were primiparae. Case 36 (aged 29) had one previous normal pregnancy in 1943.

3rd to 5th months	18,000 I.U. per 24 hours
6th and 7th months	27,000 I.U. " " "
8th month to term	36,000 I.U. " " "

The calciferol was administered in the form of pellets (Radiostol B.D.H.)—3,000 I.U. per pellet—and the women were instructed to chew the pellets like sweets, in order to ensure absorption.

The figures for Cases 24 to 36 are given in the second part of Table I.

those recommended as adequate by most authorities. Nevertheless (see Tables II and III), there were 42 per cent of negative calcium balances and 44 per cent of negative phosphorus balances in this group. A reduction in the Group III cases to 22.5 per cent negative calcium balances and 16 per cent phosphorus balance is too great to be accidental.

It is hoped that the data provided by the

TABLE II.
Calcium Balances.

	Group I	Group II	Group III
Number of balances	68	36	44
Percentage negative balances	81	44	22.5
Percentage equilibrium	9	3	4.5
Percentage positive balances	10	53	73
Group I — Controls.			
Group II — Calcium phosphate.			
Group III — Calcium phosphate plus Calciferol.			

(Balance figures under + or - 0.20 per 48 hours have been counted as "Equilibrium")

TABLE III.
Phosphorus Balances.

	Group I	Group II	Group III
Number of balances	68	36	44
Percentage negative balances	41	42	16
Percentage equilibrium	11	11	7
Percentage positive balances	48	47	77

COMPARISON OF CALCIUM AND PHOSPHORUS BALANCES.

The figures for all three Groups are shown in Tables II and III.

DISCUSSION OF THE CALCIFEROL (VITAMIN D₂) FACTOR.

The figures shown in Tables II and III provide almost conclusive evidence that calciferol has some influence on calcium, and to a greater extent on phosphorus metabolism.

Both calcium and phosphorus intake figures in Group II cases were higher than

completed survey will throw light upon the following questions which are all of considerable practical importance:

1. The mechanism of action of calciferol.
2. What is the optimum dose of calciferol at different stages of pregnancy?
3. Are mineral supplements necessary, when the proper dose of calciferol is administered throughout pregnancy?

MECHANISM OF ACTION OF CALCIFEROL.

In spite of the large amount of work done on animals, the exact mechanism of vitamin D action is still far from understood even in smaller laboratory animals. The action is

still more obscure in the more complex human organism. The most comprehensive monograph on the subject² emphasizes our ignorance. The authors of this monograph state: "Evidence is accumulating that the responses to vitamin D which have occupied most attention, that is, calcaemia, phosphataemia, modification of rates of absorption and excretion, ossification—are not primary changes, but are the signs of reactions to which they are secondary, and that back of all these there is a function of rendering calcium and phosphorus available to tissues, and a companion process of making the tissues more receptive to these ions—that is, stabilizing and integrating the relationship. How this is accomplished constitutes the major problem for investigation."

Shimotori, *et al.*³ who studied the mechanism of vitamin D action in dogs by using radioactive phosphorus found increased urinary phosphorus excretion (found also in most of our Group III cases), and concluded nevertheless that calciferol probably does not exert its effect on phosphorus metabolism by improving intestinal absorption of phosphorus, but rather by intensification of the phosphorus turnover in bone with resulting hyperphosphataemia and decreased visceral phosphorus turnover. Though there was no increase in the plasma inorganic phosphorus figure in our Group III cases (in spite of the high daily dosage of calciferol), the marked increase in urinary phosphorus excretion in relation to faecal phosphorus excretion and the greater proportion of positive phosphorus balances, suggests an important influence on foetal bone growth. The postnatal follow-up findings of all groups, together with the findings on the succeeding groups of experimental subjects, to be published later—being given varying doses of calciferol without mineral supplements—should throw more light on this subject.

WHAT IS THE OPTIMUM DOSE OF CALCIFEROL?

The doses specified above which were given to the Group III cases are much higher than those ordinarily given. They were decided upon as the result of previous experimental work in which the writer found difficulty in ensuring positive calcium and phosphorus balance throughout pregnancy on the usual doses.

A survey of the literature on this subject is not at all helpful. Park⁴ states that pregnant women should be given 800 units of calciferol per day, but admits that he is not sure that this is the correct dosage. It is to be presumed that those who are responsible for the dosage in the daily Government capsule sold to mothers at antenatal clinics (which contains 800 units of vitamin D), shared Park's opinion.

In a more recent publication⁵ McCune states that during pregnancy "an amount of vitamin D, equal to that contained in 5 teaspoonfuls of cod-liver oil, that is 1,700 units, may be required in addition to a high calcium intake to prevent a negative balance and guarantee calcium retention." Shohl⁶ in his monograph on mineral metabolism writes "Four hundred units of vitamin D and 1 quart of milk daily should be included in the diet of pregnant women." No experimental authority for either of these statements is given.

On the other hand, Steck, *et al.*⁷ proved that the tolerable limit of administration of the vitamin (without toxic symptoms) is 20,000 units per kg. per day for human and canine subjects. As the average weight of the women in Group III was 55 kg., it can be presumed that they would tolerate a dose of 1,100,000 units per day. The maximum dose given them at the end of pregnancy, that is, 36,000 units per day, allows a large margin of safety. None of these women complained of any unpleasant symptoms.

though it is doubtful whether such large doses are, in fact, necessary. In any case, the labour and postnatal details of the members of Group III do not bear out the suggestions made by such authors as Biehm,⁸ who in a paper which provided singularly little experimental evidence, suggested that intermittent daily doses of 4,000 I.U. caused calcification of the placenta, and might cause calcification in the kidney of the new-born and premature calcification of the foetal head, or Finola, *et al.*⁹ who claimed that on such minute doses as 250 units per day, there was radiological evidence of increased density of the foetal bones.

The findings in the next groups of women in this series should enable us to discover the optimum requirements for different phases of pregnancy with greater accuracy and also whether mineral supplements are necessary as well as calciferol, when adequate dietary intake of calcium and phosphorus is available.

SUMMARY.

1. Calcium intake, output and balance figures are given on 14 further cases in the series—48-hour balance periods at 6-weekly intervals throughout pregnancy.

2. The calcium and phosphorus balances of all cases in the series considered up to date are analysed in three groups:

Group I. Control on self chosen diets.

Group II. On self chosen diets, together with a supplement of calcium phosphate.

Group III. As Group II, together with large doses of calciferol.

3. The table of calcium balances shows a marked decrease in negative balances in Group II as compared with Group III, and a still further decrease in Group III. Even in Group III, however, there were 22.5 per cent negative balances. The possibility that this may be due to an excessive dosage of calciferol is mooted.

4. The table of phosphorus balances shows no difference between Groups I and II with regard to percentage of negative balances—42 per cent. In Group III there is a reduction of the percentage of negative balances to 16 per cent.

5. The mechanism of action of calciferol is discussed.

6. Our ignorance as to the optimum dosage of calciferol during pregnancy is stressed and references given to the literature on the subject up to date.

CONCLUSION.

That positive calcium and phosphorus balances throughout pregnancy in normal women cannot be ensured by a high calcium and phosphorus intake alone. The addition of calciferol is essential.

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TABLE I.
Tabulation of Calcium Intake and Output Figures.
 (The figures on each line represent the findings of a 48-hour balance period in terms of grammes of calcium element)

Calcium intake				Calcium output			
Date	Week of pregnancy	Case No.	Milk	Cheese	Other foods	Sup.	Total
			Calcium in blood	Calcium in urine	Calcium in faeces	Total calcium output	Calcium balance
6. 6.1945	20	23	2.75*	Nil	0.32	1.45	4.52
19. 7.1945	26		1.85	0.44	0.49	1.45	4.23
14. 9.1945	34		2.01	Nil	0.41	2.08	4.50
7. 3.1943	15	24	1.30	0.28	0.20	Nil	1.78
13. 4.1943	21		1.41	0.19	0.35	Nil	1.95
4. 4.1943	12	25	1.48	Nil	0.78	Nil	2.26
18. 5.1943	19		1.03	Nil	0.52	Nil	1.55
13. 7.1943	16	26	1.05	0.52	0.30	Nil	1.87
25. 8.1943	22		1.23	0.76	0.19	Nil	2.18
13. 7.1943	15	27	1.28	Nil	0.31	Nil	1.59
25. 8.1943	21		1.72	0.22	0.53	Nil	2.47
1. 11.1943	12	28	1.02	Nil	0.44	Nil	1.46
19. 2.1944	18		1.64	Nil	0.37	Nil	2.01
1. 5.1944	9	30	0.86	Nil	0.47	Nil	1.33
14. 3.1943	12	31	1.80	0.37	0.19	Nil	2.36
20. 4.1943	17		1.40	0.37	0.30	Nil	2.07
17. 4.1943	17	32	1.63	0.37	0.25	Nil	2.25
31. 5.1943	24		1.45	0.08	0.40	Nil	1.93
27. 7.1943	13	33	0.45	0.19	0.31	Nil	0.95
10. 9.1943	19		0.97	0.34	0.61	Nil	1.92
8. 1.1944	16	34	1.07	0.47	0.48	Nil	2.02
19. 9.1944	13	35	1.82	Nil	0.41	Nil	2.23
11. 11.1944	14	36	1.00	Nil	0.45	Nil	1.45
27. 5.1943	27	24	1.31	Nil	0.31	1.89	3.51
9. 7.1943	33		1.48	Nil	0.30	2.52	4.30
24. 6.1943	25	25	1.69	Nil	0.43	1.89	4.01
6. 8.1943	31		2.04	0.49	0.47	Nil	3.00
8. 9.1943	35		1.58	0.38	0.35	2.52	4.83
6. 10.1943	28	26	1.53	0.41	0.36	1.89	4.19
17. 11.1943	34		1.19	0.34	0.20	2.52	4.25
23. 12.1943	39		1.14	0.19	0.20	2.52	4.05
6. 10.1943	27	27	1.17	0.56	0.52	1.89	4.14
14. 11.1943	32		1.72	Nil	0.29	2.52	4.53
			10.3	1.19	4.72	5.91	
			10.5	0.39	5.08	2.05	
			10.0	0.58	10.95	11.53	
			9.9	0.58	4.30	4.99	
			10.0	0.69	4.30	11.53	
			9.0	0.35	2.68	3.03	
			10.0	0.70	1.36	2.06	
			9.5	0.65	2.16	2.81	
			10.0	0.84	1.83	2.67	
			10.2	0.76	2.07	2.83	
			10.4	0.46	0.99	1.45	
			10.0	0.59	2.56	3.15	
			10.6	0.37	1.01	1.38	
			10.1	0.89	1.29	2.18	
			9.8	0.75	1.98	2.73	
			9.3	0.48	2.90	3.38	
			9.3	0.75	1.98	2.73	
			10.1	0.89	1.29	2.18	
			10.6	0.37	1.01	1.38	
			9.0	0.59	2.56	3.15	
			10.0	0.46	0.99	1.45	
			10.4	0.76	2.07	2.83	
			9.5	0.65	2.16	2.81	
			10.0	0.70	1.36	2.06	
			9.0	0.35	2.68	3.03	
			10.0	0.69	4.30	4.99	
			9.9	0.58	10.95	11.53	
			10.0	0.39	5.08	7.28	
			10.5	1.27	0.78	1.37	
			10.3	1.19	4.72	5.91	

TABLE I (Continued)

Date	Week of pregnancy	Case No.	Calcium intake				Calcium in blood	Calcium in urine	Calcium in faeces	Total calcium output	Calcium balance
			Milk	Cheese	Other foods	Sup.					
6.12.1943	17	28	1.20	0.19	0.46	1.26	10.6	0.68	3.28	3.96	-0.85
10. 1.1944	22		1.35	Nil	0.49	1.26	10.6	0.68	1.70	2.38	+0.72
24. 2.1944	28		1.12	Nil	0.41	1.89	10.2	0.79	2.24	3.03	+0.37
3. 4.1944	33		1.30	0.19	0.48	2.52	9.8	0.79	3.90	4.69	-0.20
9. 5.1944	38		1.18	0.22	0.39	2.52	10.6	0.85	1.90	2.75	+1.56
4. 4.1944	24	29	1.42	Nil	0.40	1.26	9.8	0.48	0.74	2.22	+0.86
18. 5.1944	30		2.07	Nil	0.45	1.26	9.6	0.41	2.96	3.37	+0.41
25. 6.1944	35		2.02	Nil	0.40	1.89	11.2	0.33	2.16	2.49	+1.82
8. 6.1944	15	30	1.96	0.08	0.49	1.26	11.0	0.48	2.07	2.55	+1.24
4. 8.1944	25		1.45	Nil	0.50	1.26	10.7	0.77	1.20	1.97	+1.24
3. 10.1944	31		1.48	Nil	0.45	1.89	10.0	0.81	2.29	3.10	+0.72
13.11.1944	35		1.72	Nil	0.62	1.89	11.2	0.78	2.32	3.10	+1.13
2. 6.1943	22	31	1.71	0.49	0.38	1.89	10.0	0.82	4.10	4.92	-0.45
21. 7.1943	29		1.46	0.49	0.31	1.89	9.6	1.09	1.81	2.90	+1.25
1. 9.1943	36		1.22	Nil	0.16	2.52	9.8	0.44	0.02	1.46	+2.44
10. 7.1943	30	32	1.55	0.12	0.27	1.89	9.7	0.89	2.60	3.49	+0.34
16. 8.1943	35		2.13	Nil	0.30	2.52	9.6	0.80	2.30	3.10	+1.85
22.10.1943	25	33	0.74	0.22	0.35	1.26	11.9	1.14	1.78	2.92	-0.45
6.12.1943	31		0.92	Nil	0.48	1.89	11.6	0.79	2.38	3.17	+0.12
18. 1.1944	36		1.15	0.41	0.52	1.89	—	0.56	2.12	2.68	+1.29
8. 2.1944	39		1.20	0.66	0.40	2.52	10.5	0.59	1.76	2.35	+2.33
22. 2.1944	22	34	0.97	0.65	0.45	1.26	10.8	0.76	2.44	3.20	+0.13
3. 4.1944	26		1.44	0.74	0.64	1.89	10.5	0.60	2.69	3.29	+1.42
15. 5.1944	32		1.53	0.51	0.65	1.89	10.2	0.68	3.64	4.32	+0.26
15. 6.1944	36		1.12	0.22	0.70	2.52	10.0	0.33	3.20	3.53	+1.03
9.11.1944	19	35	1.41	Nil	0.50	1.26	9.7	0.57	2.85	3.42	-0.25
12.12.1944	24		1.16	Nil	0.56	1.26	10.3	0.70	1.62	2.32	+0.66
24. 1.1944	30		1.40	Nil	0.39	1.26	10.3	0.56	1.95	2.51	+0.34
8. 3.1945	36		1.18	Nil	0.31	1.89	10.3	0.76	1.05	1.81	+1.57
16.12.1944	18	36	1.22	0.48	0.54	1.26	10.2	0.72	10.10	10.82	-7.32
25. 1.1945	23		1.32	Nil	0.48	1.26	10.0	0.50	2.09	2.59	+0.47
16. 3.1945	30		1.22	Nil	0.60	1.89	9.5	0.62	2.95	3.57	+0.14
3. 5.1945	36		1.20	Nil	0.50	1.89	9.0	0.46	3.63	4.09	-0.50
31. 5.1945	40		1.60	Nil	0.40	2.52	9.7	0.22	0.72	0.94	+3.58

Pulmonary Tuberculosis and Pregnancy

BY

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THE literature on this subject is bulky, and the views expressed widely divergent. In the main, 3 aspects of the problem are dealt with: (1) Is pregnancy a danger to a woman suffering from phthisis; does it tend to aggravate active disease or to reactivate quiescent disease in the lung? (2) To what extent may tuberculous women be permitted to bear children? (3) Is phthisis an indication for artificial interruption of pregnancy? This approach is inadequate, for it leaves out of consideration many important questions which arise in the management of these cases. However; even within this restricted field of study, much of the literature has served rather to obscure the problem than to illuminate it.

The conclusions of the numerous workers are often contradictory, and this is not remarkable, for in many cases the basis on which these conclusions are founded is inadequate. Much of the literature, in short, is of no scientific value, for the material studied is incapable of supplying the answers to the questions posed. This has not deterred many writers from reaching emphatic conclusions and holding them with great tenacity. The confusing nature of much of the literature may explain, though it can hardly excuse, the remarkable neglect of this important problem in textbooks of general medicine. Even special textbooks on tuberculosis give very little space to the complication of pregnancy, which is adequately covered only in books on obstetrics. In the special literature, too, we find that many of the most ex-

haustive, objective and generally valuable studies of the subject have been made by obstetricians rather than by physicians. This is difficult to understand, for the combination of phthisis and pregnancy is frequent, and it calls for the exercise of the sort of judgment which physicians are apt to claim as their special province. Perhaps it is because they are unfamiliar with the speculative theorizing so prevalent in the literature of tuberculosis, that obstetricians have taken a more objective view of the problem. At all events, among the numerous papers on the subject a certain number are distinguished by a more scientific approach and these enable us to reach certain conclusions.

A traditional belief, existing from ancient times and expressed in the Hippocratic writings, credited pregnancy with a beneficial effect on phthisis, and this belief appears to have been general, both amongst the profession and the laity, until about 1850. During the latter half of the 19th century a number of writers expressed the view that pregnancy is harmful. This view replaced the earlier belief and gained increasing adherence until recent years, while many authorities drew the natural (though ill-substantiated) conclusion that if pregnancy be harmful to a tuberculous woman, artificial abortion must be the most satisfactory treatment. During the past 30 years the doctrinal pendulum has swung back and now occupies a more neutral position. The balance of opinion, however, still holds that pregnancy is harmful to the

tuberculous, although there is nowadays a healthy tendency to avoid sweeping generalization and to give each case individual consideration.

LITERATURE.

In 1931, Robinson¹ published the results of a questionnaire addressed to a large number of different authorities, mostly in Britain, but including some in other countries. He reported that opinion was about 5 to 1 in favour of the view that pregnancy has a harmful effect upon phthisis, though many of these authorities gave little evidence in support of this view. This attitude was also evident in a discussion between physicians and obstetricians at the annual meeting of the British Medical Association in 1936.² A majority of our specialists in tuberculosis appear to regard pregnancy as a harmful "complication" in phthisis, and in active cases not a few of them advocate artificial abortion, provided the pregnancy has not advanced beyond 3 or 4 months. Some, indeed, seem to be more emphatic in their views than the available evidence warrants.

An attempt to analyse the general literature produces a feeling of confusion rather than enlightenment and only a few representative publications can be mentioned here. (Jameson³ has written an admirable review of the literature.)

First, as to the alleged harmful effect of pregnancy on phthisis, perhaps the most frequently quoted writer is Rist,⁴ who, in a study of more than 170 cases of pregnancy associated with phthisis, found that more than 80 per cent were worse after the pregnancy and more than 50 per cent were dead within 2 years of it. These figures are alarming, but they are open to 2 objections. Firstly, inadequate consideration is given to the nature, severity and extent of the tuberculous disease, and secondly there is no control material of cases of equal severity

uncomplicated by pregnancy. Figures supporting the same view have been published by many authors, including Sergeant and Moricard,⁵ Trembley,⁶ Hutchinson,⁷ Bernard,⁸ and Norris and Murphy.⁹ It is noteworthy that those writers who produce the most alarming figures are nearly all open to the same criticism as Rist. In papers including a control study, though in a number of cases an unfavourable effect of pregnancy is claimed, its degree is seen to be very much less than that asserted by Rist. One of the best studies of this type was published in 1925 by Forssner of Stockholm.¹⁰ He found that in the less advanced cases of phthisis there was very little difference in the after histories of those women who had undergone pregnancy, as compared with those of a control series. In the more advanced cases of phthisis, however, there appeared to be a somewhat less favourable outcome in the women who had undergone pregnancy, though its degree was less than had been described by other writers. Forssner's results are summarized in Table I, taken from his paper.

A paper by Cohen¹¹ analyses the results in 100 tuberculous women who underwent pregnancy and labour, with the conclusion that "pregnancy and labour *per se* rarely exert any harmful effect on the progress of pulmonary tuberculosis."

A number of other writers have made comparative studies of the after histories of tuberculous patients, some undergoing pregnancy and some not, and have reached the conclusion that no significant difference can be shown between them. Among these are: Barnes and Barnes,¹² Hill,¹³ Brindeau *et al*,¹⁴ Glaser,¹⁵ and Schultze-Rhonhof and Hansen.¹⁶ To sum up, the bulk of the evidence indicates that in minimal or quiescent cases of phthisis pregnancy exerts no harmful effect, but in cases of more active disease pregnancy may be harmful in a proportion of cases, though it is certain that

this harmful effect has been much exaggerated by many writers.

INFLUENCE OF PREGNANCY ON PHTHISIS.

In what way may pregnancy exert a harmful effect on phthisis? Many theories have been advanced, some of them rather academic. Chemical factors, e.g. depletion of calcium or rise in cholesterol content

fact of pregnancy which is responsible for the relative "anergy." Most stress has been laid on mechanical factors: the enlargement of the uterus and the consequent progressive rise of the diaphragm during pregnancy. The increasing restriction of movement of the diaphragm was formerly held to be the harmful factor, but more recently this theory was seen to be in conflict with the theory of collapse therapy and

TABLE I.
Comparison of after-history of women suffering from phthisis during a two-year period after pregnancy with that of similar patients in whom there was no gestation which could have influenced the development of the disease (after Forssner).

Observation period	Stage (Turban)		Aggravated Per cent	Dead Per cent
One year: (Pregnant: 203 cases) (Non-pregnant: 396 cases)	I	Pregnant	28	1
		Non-pregnant	23	2
	II	Pregnant	33	6
		Non-pregnant	21	6
	III	Pregnant	19	46
		Non-pregnant	20	37
Two years: (Pregnant: 185 cases) (Non-pregnant 359 cases)	I	Pregnant	28	12
		Non-pregnant	27	14
	II	Pregnant	35	17
		Non-pregnant	30	14
	III	Pregnant	4	70
		Non-pregnant	10	63

of the blood, have been invoked, though the latter has been held to be protective rather than harmful. Some authors, e.g. Bar,¹⁷ have pointed to the decline in tuberculin sensitivity which is observed in some cases of phthisis during pregnancy and have claimed that these are the cases in whom danger of aggravation of the lung disease exists. Bar went so far as to advocate therapeutic abortion in cases in whom the tuberculin reaction is absent or feeble, though it would seem that it might be the severity of the lung disease rather than the

has accordingly been modified. It is now held that the elevation of the diaphragm during pregnancy is a favourable factor, but that the sudden descent during labour is harmful. This is held to explain improvement of the lung disease during pregnancy, which is sometimes observed, followed by rapid deterioration after delivery. It is true that some cases of phthisis undergo exacerbation during or shortly after the puerperium. The observation of a case of this type is sometimes responsible for emphatic views on the danger of pregnancy

to the tuberculous, though a more general view of the evidence might produce less extreme views. A factor of great importance which has been ignored by many writers is the influence of social and environmental conditions. It is hardly necessary to invoke highly theoretical conceptions of biochemical, endocrine, or even mechanical changes to explain a deterioration in the lung disease of a recently delivered woman when we consider the drastic changes in her life which the advent of an infant brings. The strain of lactation, the physical exertion of caring for a baby and washing its clothing, disturbed sleep, the added difficulties of housework, shopping and caring for the rest of the family, to say nothing of the financial burden represented by the new child, seem more than enough to account for an exacerbation of the lung disease. All these adverse factors apply in inverse proportion to the family income. In this, as in all other aspects of tuberculosis, the social factor is important, but it is often little heeded in academic controversy. It may well be that the widely different conclusions reached by different authors as to the effects of pregnancy on phthisis are largely due to neglect of the social factor, which can vitiate the most carefully chosen cases.

THERAPEUTIC ABORTION IN PHTHISIS.

This subject appears to provoke as much heated polemic as any other in the whole field of medicine, but a brief study of the available evidence leaves little doubt as to the correct attitude. As concluded above, a certain number of cases of phthisis deteriorate after pregnancy, though this proportion is not large and may well be explained largely by social factors. However, the possibility of exacerbation of the lung disease is regarded by many as adequate grounds for advocating abortion

as a method of treatment. If this is to have any scientific justification, evidence must be sought showing that in general the harmful effects are avoided if the pregnancy be interrupted. A study of the literature will soon convince any impartial person that no such evidence exists. There are relatively few studies in which an adequate series of tuberculous women in whom pregnancy has been artificially interrupted is compared with a series of cases of equal severity undergoing full time pregnancy and labour. Such studies as do exist have failed to show that an artificially interrupted pregnancy has in general any less unfavourable effect on the course of the lung disease than a full time pregnancy. Some few authors, for example, Czazkes¹⁸ have claimed a more favourable outcome in aborted cases. Pissavy and Lejard,¹⁹ in a criticism of Czazkes' paper, have pointed out that his conclusions were open to question, since he does not give details of the severity of the cases considered, and that even if the most favourable possible interpretation were accepted it would mean that to secure a $3\frac{1}{2}$ -year survival in 17 women it would be necessary to sacrifice 100 pregnancies. This means the certainty of unnecessarily sacrificing about 80 infants, and since it is impossible to decide in any particular case whether the outcome will be favourable or otherwise it is not easy to justify sacrifice of the infant. Barnes and Barnes¹² found that the outcome in a series of women in whom pregnancy had been artificially interrupted was less favourable than in those in whom it had proceeded to term, and this result has also been obtained by a number of other workers.

Even those who advocate therapeutic abortion are agreed that it must be completed within 3 to 4 months of conception. Since relatively few cases come under observation so early, and since the benefit

in any particular case is problematical, we must conclude that abortion is justified only in a small number of cases where special circumstances exist. It can play little part in the solution of the difficult problems which arise in the treatment of pregnant tuberculous women.

As regards the child, it is clear from many studies that the infant of a tuberculous mother has almost as good a chance of being normal at birth as that of a healthy woman. Congenital tuberculosis is extremely rare, and provided the child can be protected from the risk of infection by its mother after birth its chances of survival and normal development are very good.

THE EXTENT OF THE PROBLEM.

Pulmonary tuberculosis stands first among all causes of death in women of child-bearing age. In England and Wales, in 1936, respiratory tuberculosis accounted for 25 per cent of all deaths in females of the age group 15-44 years. This is 3 times as many as deaths due to puerperal causes of all kinds.

It is difficult to assess the incidence of this in association with pregnancy, for as yet there is little information available on this point. Browne²⁰ stated that 82 cases of phthisis had been encountered among a total of 16,000 pregnancies observed at University College Hospital from 1928 to 1937 (incidence 0.51 per cent). Brindeau *et al.*¹⁴ reported a total of 254 cases among 32,667 pregnant women admitted to the Tarnier Clinic during a 10-year period (incidence 0.77 per cent). Bridgeman and Norwood²¹ reported 134 cases in 14,000 parturient records from the Johns Hopkins Hospital, Baltimore (incidence 0.96 per cent). None of these authors states the proportion of cases of active disease, and as their diagnostic standards may vary these figures are

probably not strictly comparable. It is evident that the clinical examination made as part of the routine antenatal supervision at most maternity hospitals will reveal only a proportion of all cases of phthisis, and that if cases are not to be missed some form of radiological examination is essential. An investigation of this problem was begun at Paddington Hospital in 1943, and from that year a screen examination of the chest has been included as part of the routine for all women attending the antenatal department, as soon as possible after the first attendance.²² In every case where screen examination shows possible pulmonary disease a full-size film is taken. From January 1943 to April 1946 a total of 4,430 women have been screened and the results are summarized in Table II.

Only one other survey of this type has been traced in the literature, that of Eisele *et al.*,²³ who carried out screen examination of the chest under rather similar conditions in a series of 10,968 women attending the antenatal department in a Chicago hospital during the years 1934-41. Table III summarizes the findings in all the above-mentioned series, together with those in a series of 59,951 W.A.A.F. recruits examined by miniature radiography (Trail *et al.*²⁴), and some figures showing the number of new cases of phthisis discovered in women aged 15-45 years in 1937 in the County of London.

For various reasons it would be unwise to compare these figures too closely, as they may be influenced by unknown factors. Nevertheless, if we compare the results of the Paddington screening survey with those obtained by rather similar methods in Chicago, we see that we have to reckon with an incidence of probably more than 0.5 per cent of cases sufficiently severe to need immediate admission to hospital. Nearly 60,000 births occur annually in the

County of London, and approximately 10 times that number in England and Wales, and if these figures are capable of general application it becomes evident that a hospital problem of great magnitude is at present being avoided only by our failure to diagnose more than a small proportion of the existing cases. Only radiological methods are adequate for the discovery of the unsuspected cases, and the need for

indicated in Table III, an incidence of 0.5 per cent of severe active cases would mean a total of over 280 cases annually in the County of London alone, whereas at present the number of pregnant tuberculous women admitted to hospital from the L.C.C. area is probably not much more than 50 annually. The problem of providing sufficient beds for treatment of the cases discovered is a corollary of all mass

TABLE II.
Screening Survey at Paddington Hospital.

Total number of pregnant women screened ...	4430	
Total number of patients radiographed ...	249	(5.70 per cent)
Cases of pulmonary tuberculosis:		
Active, requiring immediate admission ...	27	(0.61 per cent)
Possibly active ...	11	(0.25 per cent)
Probably inactive ...	30	(0.67 per cent)
Total cases of tuberculosis ...	68	(1.53 per cent)
(Excluding calcified lesions)		
Calcification shadows ...	39	
(Only large or multiple ones filmed)		
Non-tuberculous conditions, various ...	27	
Azygos vein lobe ...	10	(0.22 per cent)
Increased vascular shadows ...	34	

routine radiological examination of the chest in pregnant women appears to be at least as pressing as in those other groups of the population to which it is now being applied. Of the methods available miniature radiography would probably be the most satisfactory but there are at present certain difficulties in applying it. Until these are overcome screen examination could largely meet the need, and it has the advantage of being already available at most hospitals. Experience at Paddington Hospital has shown that it can be quite easily introduced, and that the co-operation of the mothers is very good.

MANAGEMENT OF PREGNANCY IN TUBERCULOUS WOMEN.

Diagnosis of the many unsuspected cases is only the beginning of the problem. As

radiological surveys, and in the case of pregnant women special difficulties arise, for skilled obstetric care must be available as well as skilled treatment for the lung disease. At present, in many parts of the country, arrangements for the care and treatment of pregnant women suffering from phthisis are inadequate even for the manifest cases, and pregnant women experience even more difficulty than others in obtaining prompt treatment. None the less, provisions for treatment can be made only when the full extent of the problem is revealed, and the wider use of radiological methods is urgently required. In addition to its advantages for the patients, it would create an admirable material for research into the effects of pregnancy upon phthisis, for the cases discovered would be unselected. Existing studies are mostly

based upon cases revealing themselves by symptoms, and a brief experience of radiological survey methods will soon convince anyone that these are an unrepresentative selection.

patients under treatment. The long period of in-patient treatment and separation from the child make many women reluctant to accept treatment at all. A determined effort must be made to mitigate the diffi-

TABLE III.
Incidence of Pulmonary Tuberculosis in Pregnancy.

Author etc.	Method of survey	Total women	Cases of phthisis	Per cent of total	Active phthisis per cent
Browne U.C.H. 1928-37	Clinical	16,000	82	0.50	?
Bridgeman Johns Hopkins Baltimore	Clinical	14,000	134	0.96	?
Brindeau Tarnier Hospital 10 years	Clinical	32,667	254	0.77	?
Eisele, <i>et al.</i> Chicago 1934-41	Screening	10,968	110	1.38	0.67
Jacobs Paddington 1943-46	Screening	4,430	68	1.53	0.61

General Incidence in Women of Child-bearing Age

Trail, <i>et al.</i> W.A.A.F. 1941-44	Miniature radiography	59,951		0.94	0.36
L.C.C., 1937 Females 15-45 years	New cases phthisis diagnosed	1,071,000	2217	0.21	?
County of London, 1937, total births				56,875	
Cases of phthisis (assuming a rate of 0.50 per cent)				282	

Even with the provision of more beds in institutions suitable for the handling of pregnancy as well as the treatment of phthisis, in many cases social factors add greatly to the difficulties of bringing

culties arising in the home when the mother has to enter hospital. One form of help would be the provision, without financial burden, of domestic help in the home, as well as the necessary financial help to meet

the expenses which tuberculosis imposes and which bear so hardly on all but the wealthiest homes.

We are now in a position to lay down certain principles governing the management of a pregnant woman suffering from phthisis:

(1) *Therapeutic Abortion.*

This is of little help. There are a certain number of cases in which it is indicated, perhaps mainly on social grounds. It can be considered only in the first 3-4 months of pregnancy.

(2) *Treatment of the Lung Disease.*

Pregnancy is an added indication for the promptest application of all possible methods of treatment, especially effective collapse therapy, on the usual indications. This will help to guard the lung against the possible ill-effects of labour. Treatment must be continued after labour, its duration being governed by the usual considerations.

(3) *Obstetric Care.*

Skilled obstetric care must be provided, preferably in the same institution where the lung disease is to be treated.

(4) *Care of the Infant.*

The child usually has to be separated from the mother at birth. If no suitable relative is available to care for it, the child has to be admitted to an institution, either an ordinary residential nursery or a special "preventorium" of the type successfully developed in some Continental countries.

(5) *Help in the Patient's Home.*

Domestic help and financial assistance in the home must be provided where necessary, as well as the usual valuable supervision by health visitors.

How can these principles best be followed in practice? During recent years considerable attention has been devoted to

the problem by some of the larger health authorities. In the L.C.C. area, most cases are admitted to Grove Park tuberculosis hospital and are transferred for obstetric care to the nearby Lewisham General Hospital, where a special department has been established for them in the maternity block. After delivery the patients are retransferred to Grove Park Hospital and in some cases subsequently to country sanatoria. The Essex County Council has organized a special obstetric unit for tuberculous women at Black Notley Sanatorium, so that they may remain in the same institution throughout their treatment. The infants are usually admitted to ordinary residential nurseries.

In the areas of the larger health authorities, such arrangements as these have hitherto proved adequate to deal with the relatively small numbers of cases discovered at the antenatal clinics and tuberculosis dispensaries. If radiological methods were generally applied in antenatal departments, however, it would become necessary greatly to extend these facilities. It is doubtful whether the situation could be met by an attempt to organize maternity units in sanatoria, for these are often situated far from hospital centres and the problem of providing them with specialist obstetric staff would be very great. Moreover, the difficulty of inducing pregnant women to go into hospital is increased if beds be offered in institutions far from their homes. The best answer to this problem would seem to lie in making use of the large general hospitals, which have both specialist medical staff and specialist obstetric staff available, and are situated within easy reach of most patient's homes. The cases could then be promptly admitted to hospital and receive all necessary treatment, being retained in the general hospital until well after the puerperium. Finally, when the tuberculous disease is satisfactorily controlled, they

could be transferred to country institutions for the more ambulant stages of their treatment. Throughout the more critical period of treatment, and during labour and puerperium, the patient would then be under the care of specialist medical and obstetric staff, and would also be within easy reach of her relatives. While the patient is in hospital the provision of domestic help in the home can help to set her mind at rest and make her more ready to accept treatment. After she returns home it is no less essential to spare her excessive domestic drudgery.

In conclusion, the importance of the social factor must again be emphasized. The home difficulties are not easy to overcome, but unless we can do this our best efforts in the dispensary, the hospital and the sanatorium are likely to be wasted.

SUMMARY.

1. Current views of the effect of pregnancy upon pulmonary tuberculosis and the indications for therapeutic abortion are briefly discussed.
2. Figures are given showing the incidence of pulmonary tuberculosis in a series of 4,430 pregnant women, as revealed by screen examination.
3. The problems encountered in the management of pregnancy in tuberculous women are discussed and some principles for their solution enunciated.

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The Cause of Prolapsus Uteri in Women in the Light of Perineal Prolapse in Mice

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THE condition about to be considered seems to be one of those many ailments whose aetiology in man can be elucidated by a study of their occurrence in lower animals.

Spontaneous prolapse of the uterus and vaginal perineum has occurred somewhat frequently among mice in this institution. The lesion has been specially investigated in our untreated 'Stock Breeders'. All these mice have been mated within their own group, though brother \times sister mating has not been strictly maintained. Prolapse of the rectum is also seen occasionally in this stock and occurs in the male as well as in the female; but even in the female prolapse of the rectum occurs independently of vaginal and uterine prolapse, and the following remarks are confined to the latter condition.

Clinical experience has taught that prolapse of the perineum in women is a sequel to parturition, and the condition is attributed usually to laceration or overstretching of the pelvic tissues, the evil effects of these lesions being enhanced by gravity through the upright stance. Such lesions of the pelvic tissues in women, however, are purely conjectural and perhaps do not exist. In any event the abnormality as it is seen in our mice cannot be attributed to such alleged causes, for in them the prolapse depends neither on labour nor the upright stance, and is in fact associated

with some degree of infertility. We have studied all our female 'Stock Breeders', numbering 547, which were born in the years 1943 and 1944 and lived for 6 months or longer; every one had cohabited with a male. Prolapse of the vaginal perineum was found in 48, or 8.6 per cent of these mice. The condition was not peculiar to advanced life; the earliest age at which it was recorded was 83 days, and the defect was noted in many instances between that age and 200 days. The general fertility in this particular stock of breeding mice has been small; even so, a total sterility was commoner in those which ultimately had prolapse than in those which remained free from this lesion, as shown below.

	Total	Number sterile	Per cent sterile
Mice with prolapse ...	48	33	68.7
Mice without prolapse	499	232	46.6

Furthermore, the mice which eventually showed prolapse, even though they were occasionally fertile in early life, bore fewer litters than the others.

	Total number of litters	Average number of litters per mouse
Mice with prolapse ...	19	0.39
Mice without prolapse	575	1.15

These figures indicate that the perineal defect was associated with an early onset of sterility and was not the effect of parturition.

When the condition is examined in the living mouse the earliest sign to be noticed is a slight patency of the vagina with a consequent exposure of a small glistening area of the anterior vaginal wall (Fig. 1). This condition may be noted at a stage before the other external signs of prolapse have become manifest as they are in Fig. 2. Postmortem examinations yield noteworthy information. On opening the abdomen an early sign is a sinking of the bladder and the lower ends of the uterine cornua below the brim of the pelvis, and it is remarkable that in every instance of the lesion, incipient or advanced, investigation has revealed an enlargement of the vagina (Fig. 3). It appears in fact that this vaginal enlargement has an important share in the etiology of the prolapse and probably is the initial defect.

Various incidental complications of the lesions have been noted, including hydro-nephrosis, abnormal distension of the uterus with clear fluid, and distension of the intestines; such complications may be the result of paresis, partial obstruction through kinking, or both factors combined.

Hypertrophy of the uterus with luteinization of the ovaries is common, and even though the mice have not littered, the symphysis pubis is apt to be mobile without obvious separation of the bones. Perhaps some of these concurrences may have been caused by the unnatural stimulation of the vaginal end of the uterus to which its prolapsed position makes it liable, for it has been shown by various authors that pseudopregnancy can be induced in animals by artificial stimulation of the cervix uteri.^{1, 2, 3, 4, 5}

It has not been possible to attribute these cases of perineal prolapse in mice to a

mendelian cause; they are distributed evenly throughout our stock, and obviously interfere with procreation.

THE BEARING OF THESE NOTES ON HUMAN PATHOLOGY.

From these observations on mice an interesting point arises in connexion with human pathology. For it seems possible that in women, as in mice, chronic dilatation of the vagina with perineal prolapse may be the result, not of any initial laceration or stretching of the pelvic ligament during labour as commonly thought, but of a failure of the vagina to involute completely afterward. If this be the case it is conceivable that our methods of treating this malformation may become modified; we may be able, indeed, to prevent its occurrence. To effect such a prophylaxis it will be necessary to watch the course of post-parturitional involution of the vagina as shown by its size and muscular tone and to recognize a completion of the process.

SUMMARY.

Prolapse of the vaginal perineum has occurred spontaneously in 8.6 per cent of our female 'Stock Breeders'. The condition is not a consequence of parturition; it is associated with infertility and its primary manifestation appears to be a persistent dilatation of the vagina. The abnormality in mice is believed to throw light on the aetiology of *prolapsus uteri* in women.

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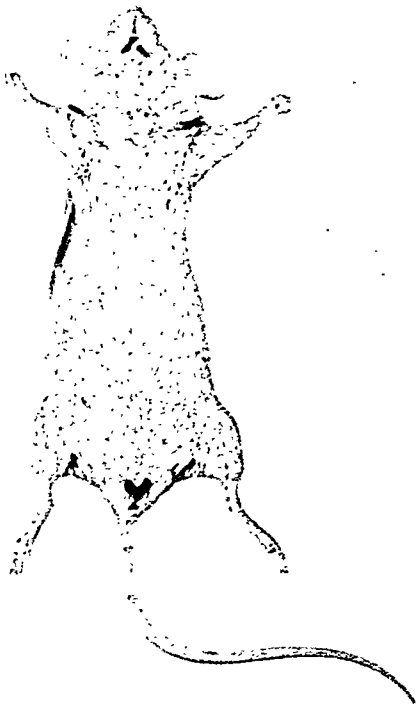


FIG. 1.

Mouse 401. Early stage of prolapse in a sterile mouse aged 83 days. Condition verified by postmortem examination. Vagina enlarged, orifice slightly patulous, bladder below pelvic brim.

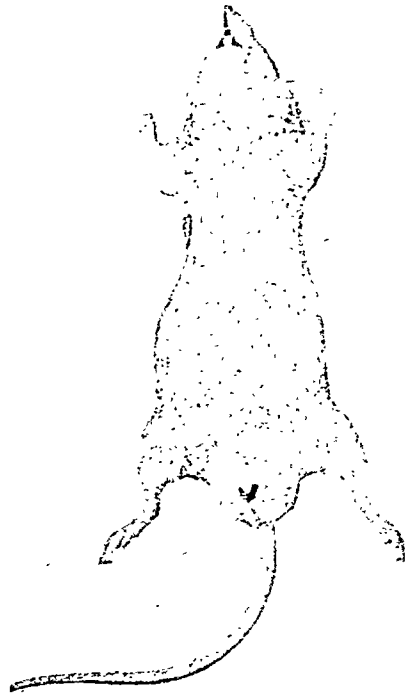


FIG. 2.

Mouse 400. Later stage of prolapse in a sterile mouse aged 119 days. Condition as in above except much more advanced. The uterus, especially the left cornu, was distended with clear fluid. Diameter of right horn 1.6 mm., of left horn 5.8 mm.

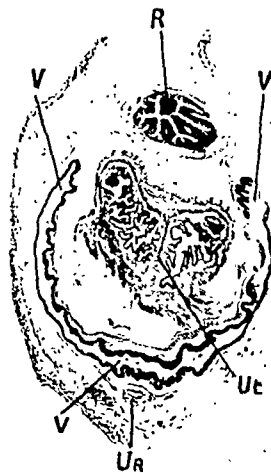


FIG. 3.

Mouse 406. Photograph of a coronal section of the prolapsed perineum in a sterile mouse of 169 days. The middle of the photo is occupied by the two united lower ends of the prolapsed uterus which are surrounded by a greatly dilated vagina. $\times 5$

R. Rectum; Ut. Uterus; V. Vagina;
Ur. Urethra.

H.B.

ROYAL COLLEGE OF OBSTETRICIANS AND GYNAECOLOGISTS.

A Meeting of the Council was held on Saturday, May 25th, 1946, in the College House, with the President, Mr. Eardley Holland in the Chair.

The following were formally admitted to the Fellowship by the President :

Arthur Capel Herbert Bell	Mabel Florence Potter
John Lyle Cameron	David Michael Stern

in absentia :

Edward Keelan
Newell Willard Philpott

The following were formally admitted to the membership by the President :

Constance Lang Beynon	Emilie Ellen Guthmann
Ernest William Cornwall Buckell	Werner Paul Hirsch
Walter Calvert	William Kearney
Raymond Gerard Cross	Arthur Harold Colyear Walker
Gilbert Dalley	Margaret Weddell
Perla Greeves	

in absentia :

Sadashiv Narayan Garde

The Council acknowledged with grateful thanks a gift of £1,000 from Sir William Fletcher Shaw, to found a lectureship in memory of his son William Meredith Fletcher Shaw, who fell in Normandy in 1944, to be awarded annually to a senior Fellow of the College.

The Annual General Meeting of the College was held on Saturday, May 25th, 1946, in the College House, with the President, Mr. Eardley Holland, in the Chair.

The following were elected to Council in place of those retiring by statutory rotation :

Representative of the Fellows :

Robert Henry Mulhall Corbet	Arthur James McNair
Arthur Alexander Gemmell	Ernest Farquhar Murray

Representative of the Members :

Bryan Leslie Jeaffreson
James Sinclair Quin.

Professor Hilda Lloyd and Mr. L. C. Rivett were co-opted to the Council for special purposes.

ROYAL COLLEGE OF OBSTETRICIANS AND
GYNAECOLOGISTS

D.OBST. R.C.O.G.

NOTICE is hereby given that Regulation 3, relating to practitioners qualified over ten years, has been reinstated. Applications may be considered forthwith under that Regulation.

ROYAL SOCIETY OF MEDICINE

THE NICHOLS FELLOWSHIP

APPLICATIONS are invited for the above Fellowship, the emoluments of which are at the rate of £200 per annum and £25 for expenses.

The research is to relate to the aetiology, pathology, prevention or treatment of puerperal infection.

The applicants should give a précis of the proposed scope of the research and where it is to be carried out.

In the first instance the Fellowship shall be awarded for one year and may be continued for a second year after consideration of a report of the work already done.

Applications should reach the Secretary, Royal Society of Medicine, Wimpole Street, London, W.1, on or before September 30th, 1946.

INDEX TO CURRENT LITERATURE

In this Index an endeavour will be made, so far as conditions permit, to maintain an up-to-date record of all titles bearing on obstetrics and gynaecology and the infant. The classification aims at making immediately available for the reader the titles under the various subject headings. In the majority of instances the title is obtained from the original publication. Where this has been impossible, the title has been obtained from the abstracting journal shown in brackets. Reprints will be welcomed and should be sent to the Editor.

Any inquiries should be addressed to Miss D. F. Atkins, British Post-graduate Medical School, Ducane Road, London, W.12.

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The Superiority of the South African Negro or
Bantu as a Parturient

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PART I.—THE SIZE OF THE BANTU HEAD
AT BIRTH.*

THE Bantu female pelvis has been compared with that of the Bantu male.¹ In comparing the female pelvic girdle of different racial groups, it is of value to know the relative size of the foetus for the respective races. For this reason an analysis of the gross birth-weight in over 2,000 cases was published;² but it is obvious that birth-weight would vary with good or poor nutrition during intrauterine life, probably in the main owing to the quantity of subcutaneous fat laid down in the foetus. While the mean Bantu weight was about 6 $\frac{3}{4}$ pounds, the mean in a smaller series receiving good antenatal care was 7 $\frac{1}{4}$ pounds, a near approach to the average for any prosperous European community. It is, therefore, of importance to assess the size of the head in the Bantu newborn, for this is the biggest part of the foetus to pass through the birth canal. The correlation table (Table I) demonstrates that in the newborn there is not a very marked relation between weight and the area of a cross-section in the plane of the occipito-frontal and biparietal diameters of the skull.

*This paper was presented as Appendix 3 of a D.Sc. Thesis submitted to the University of the Witwatersrand, South Africa.

Measurement was carried out on 500 heads of which two-thirds were Natal Zulu, one-fifth Basuto, and the rest Xhosa, Swazi, and Mpondo. Males and females were taken at random, and no separate analysis is shown for the sexes.

The birth-weight was observed in all cases, and on the day of birth the following head diameters were measured: the occipito-frontal, biparietal, suboccipito-bregmatic, and mentovertical. Areas were calculated to represent a cross-section of the greatest part, as it traverses the pelvis, of (a) the well-flexed head (biparietal and suboccipito-bregmatic as axes), and (b) the deflexed head (biparietal and occipito-frontal as axes). The correlation coefficient and regression equation for weight and area were calculated.

The measurements considered are those of the vault of the cranium, because the latter forms the major portion of the skull. In the full-time foetus the face, mandible, and temporal bones are small, the size of the head depending on the four large squamous bones, that is, the two parietal, the frontal, and the occipital.

Mean birth-weight. For 500 babies ranging in weight between 60 ounces (3 pounds, 12 ounces), and 178 ounces (11 pounds, 2 ounces), the mean weight was

112.13 \pm 0.71 ounces, standard deviation 15.83 ounces, and coefficient of variation 14.1 per cent. This weight averaged approximately $\frac{1}{4}$ pound more than that of the larger series¹ referred to above. Only 7 babies weighed were under 5 pounds, their occipito-frontal-biparietal plane areas

ment of practical value, and one which can be taken accurately in all cases; moreover, Williams⁴ and De Lee⁵ recommended these termini for the diameter. As the last-mentioned authorities are found in the Scammon and Calkins³ list of 25 other authors, it may be assumed that some of

TABLE I.
Bantu Newborn.

Correlation table for birth-weight and the area of a cross-section in the plane of the occipito-frontal and biparietal diameters of the skull.

Head area (sq..cm.)	Birth-weight in pounds									Total
	3	4	5	6	7	8	9	10	11	
60	-	-	2	3	-	-	-	-	-	5
65	1	1	6	11	8	2	-	-	-	29
70	-	2	15	36	22	1	-	-	-	76
75	-	3	12	60	30	11	3	-	-	119
80	-	-	11	59	48	16	1	1	-	136
85	-	-	4	32	40	17	5	-	-	98
90	-	-	1	5	11	7	2	-	-	26
95	-	-	-	2	4	1	1	-	-	8
100	-	-	-	-	1	-	-	-	-	1
105	-	-	-	-	1	-	-	-	-	1
110	-	-	-	-	-	-	-	-	1	1
Total	1	6	51	208	165	55	12	1	1	500

Correlation coefficient + 0.364 \pm 0.045

varying between 65 and 80 sq. cm.; 5 corresponding areas of heavier babies were below 65 sq. cm.

Occipito-frontal diameter. The mean length of this diameter was 11.30 \pm 0.03 cm., range 9.75 to 13.5 cm., standard deviation 0.64 cm., and coefficient of variation 5.67 per cent. Moulding during parturition may increase or decrease this diameter, usually with a corresponding inverse change in both suboccipito-bregmatic and biparietal diameters.

Scammon and Calkins³ give a list of authors who have published average values for this diameter. Unfortunately Scammon and Calkins measured from glabella toinion, whereas the Bantu diameter was the greatest distance between occipital and frontal bones. The latter is the measure-

the authors measured the diameter in the manner used for the Bantu. In 12 of the 25 series the mean was less than that for the Bantu, and in 1 equal to the Bantu mean. De Lee⁵ who states that his figure is based on a large number of measurements showed an average of 11 cm., Williams⁶ a corresponding mean of 11.75 cm.

The mean occipito-frontal diameter in the Bantu may, therefore, be claimed to correspond with that found for Europeans.

Suboccipito-bregmatic diameter. With a range for this diameter of 7.25 to 12 cm., the mean was 9.68 \pm 0.03 cm., standard deviation 0.63 cm., and coefficient of variation 6.50 per cent.

Scammon and Calkins³ give a list of 17 observers publishing averages for this

diameter, and of these 8 found figures lower than the Bantu mean of 9.68 cm.

Biparietal diameter. This is the greatest width of the head between the parietal eminences. The figures for the biparietal diameter were as follows: mean 9.22 ± 0.02 cm., standard deviation 0.53 cm., coefficient of variation 5.74 per cent, and range 7.5 to 10.75 cm.

Scammon and Calkins³ cite 47 series from 38 authors who publish means for the biparietal diameter: in 15 series the means are smaller than that for the Bantu. Both De Lee⁵ and Williams⁶ show a mean of 9.25 cm. as compared with 9.22 cm. for the Bantu mean biparietal diameter.

If the area of a cross-section of the head with biparietal and occipito-frontal as axis is calculated from the means of these diameters, it is found that the Bantu area is greater than that for Scammon and Calkins³ and De Lee,⁵ but slightly less than that for Williams.⁶

Mentovertical diameter. For 475 heads with a range for this diameter of 11 to 15.5 cm., the mean was 13.27 ± 0.03 cm., standard deviation 0.74 cm., and coefficient of variation 5.48 per cent. The measurement was made from the point of the chin to the most distant point on the vertex (parietal bone). Scammon and Calkins define the posterior point of this diameter as the external occipital protuberance, as in the case of their occipito-frontal diameter. From the table of authors presented by Scammon and Calkins,³ comparison with the Bantu mean for the mentovertical diameter shows that in 15 series out of 34 the mean diameters were less than that of the Bantu. The Bantu figures lay midway between those of De Lee (13 cm.) and Williams (13.5 cm.).

Area of cross-section with biparietal and suboccipito-bregmatic diameters as axes. For 500 areas calculated from the ellipse formula, the range was 50.2 to 99.3 sq. cm.,

the mean 68.64 ± 0.28 sq. cm., standard deviation 6.33 sq. cm., and coefficient of variation 9.23 per cent. Only 7 areas were below 55 sq. cm. and 3 above 85 sq. cm., the deviations inside this range being uniformly distributed.

In English obstetric teaching the diameters under consideration are given as $3\frac{3}{4}$ inches each. This would give an area of 71.3 sq. cm. Although such a difference from the Bantu might be significant, both de Lee's and Williams' series give an area calculated from mean diameters which is less than the corresponding Bantu area.

The correlation between birth-weight and this area is shown in Table II. The coefficient of correlation between these dimensions was found to be $+0.323 \pm 0.045$, and being 7.2 times its standard error it is highly significant. The regression equation for the line was found to be

$$W = 0.05045A + 3.545 \text{ where}$$

$$W = \text{weight in pounds}$$

$$\text{and } A = \text{area in sq. cm.}$$

$$Sw = \sigma w \sqrt{1 - r^2}$$

$$= 0.936 \text{ pounds.}$$

As an approximation it may be said that the weight of the foetus is equal to the sum of $1/20$ of the area and $3\frac{1}{2}$ lb. The error of prediction in using this equation is about 15 ounces.

Area of cross-section with biparietal and occipito-frontal diameters as axes. The range in 500 calculated areas was 62.0 to 112.7 sq. cm. with a mean of 80.64 ± 0.32 sq. cm., standard deviation 7.24 sq. cm., and coefficient of variation 8.97 per cent. Five areas only were below 65 sq. cm. and 3 above 100 sq. cm.

The correlation between birth-weight and the biparietal \times occipito-frontal area is shown in Table I. The coefficient of correlation between these dimensions was found to be $+0.364 \pm 0.045$. This coefficient is more than 8 times its standard error, and may be accepted as being certainly signifi-

TABLE II.
Bantu Newborn.

Correlation table for birth-weight and the area of a cross-section in the plane of the suboccipito-bregmatic and biparietal diameters of the skull.

Head area (sq. cm.)	Birth-weight in pounds									Total
	3	4	5	6	7	8	9	10	11	
50	-	-	3	4	-	-	-	-	-	7
55	1	1	5	11	7	3	-	-	-	28
60	-	1	18	53	22	7	1	-	-	102
65	-	2	9	67	54	16	2	-	-	150
70	-	2	12	62	62	18	3	-	-	159
75	-	-	1	10	9	7	2	-	-	29
80	-	-	1	3	10	3	4	1	-	22
85	-	-	-	-	1	1	-	-	-	2
90	-	-	-	-	-	-	-	-	-	-
95	-	-	-	-	-	-	-	-	-	-
Total	1	6	49	210	165	55	12	1	1	500

Correlation coefficient $+ 0.323 \pm 0.045$

cant. The relationship between weight and area is a rectilinear one, and the regression equation for the line was found to be

$$W = 0.04975A + 2.988 \text{ where}$$

W = weight in pounds,

and A = area in sq. cm.

$$Sw = \sigma w \sqrt{1 - r^2}$$

$$= 0.921 \text{ pounds}$$

The standard error for this equation is thus 0.921 lb., i.e. the standard error of prediction in using the equation is 14 $\frac{3}{4}$ ounces.

CONCLUSION.

From the data here reported on the dimensions of the head at birth, it must be concluded that the difference between Bantu and European foetal heads at term is not considerable. While there is great variability between the Bantu and certain European figures, many of the latter are smaller than the Bantu averages. Evidence has not been found to prove that the Bantu newborn has a smaller head than the European at birth.

Note on the correlation tables. It is of great value for the obstetrician to observe the relationship that exists between foetal

weight and the size of the foetal head. The general impression is that a relatively large foetus has a relatively large head; and if disproportion is being estimated, the size of the foetus as judged by palpation is recognized to be an important factor. This view is sound in many cases, but the correlation tables demonstrate that a small foetus may have an unexpectedly large head and thus be responsible for serious obstetrical errors. Conversely, but with less danger, unnecessarily radical treatment may be adopted because a foetus which is estimated to be large has a relatively small head.

In the tables presented only birth-weights are considered, and the size of the head is based on the areas of cross-sections of the head in two different planes. It will be observed that:

1. Fifteen babies weigh under 6 lb. and still have the greater area between 75 and 80 sq. cm., the mean for this area being 80.64 sq. cm. Similarly, 11 babies weigh under 6 lb. and have a lesser area of 65 to 70 sq. cm., whereas the mean for this area is 68.64 sq. cm.

2. Conversely, there are 17 babies

weighing over 8 lb. which have the greater area below the average, and 11 babies weighing over 8 lb. have the lesser area below 65 sq. cm.

3. One baby weighing 10 to 11 lb. has a "greater head area" which is equal to the mean.

Two babies weighing only 4 to 5 lb. have the "lesser head area" greater than the mean.

4. Babies weighing 9 lb. show a range of the lesser area between 60 and 85 sq. cm., and a range of the greater area between 75 and 100 sq. cm. A range of the same order is seen to occur for most of the other weight groups.

The conclusion drawn from the correlation tables is that at term there is a well marked relationship between foetal weight and the size of the foetal head. There are important exceptions, however, in which a small baby may have a big head and vice versa. And it is these exceptional cases that are of importance to the clinician. When the obstetrician uses his skill in assessing foetal proportions in a case of disproportion, he must be armed, therefore, with the knowledge that head and body size may not be proportional.

PART II.—AN ASSESSMENT OF PELVIC CAPACITY AS A CAUSE OF DYSTOCIA IN THE SOUTH AFRICAN NEGRO OR BANTU.

INTRODUCTION.

Some Observations on Labour in the South African Negro.

DOES the primitive woman really respond to labour as we are led to believe? Our experience in South Africa is almost confined to the urban Native, if by this we mean that we are not privileged to observe the woman under tribal conditions repairing alone to the Bush to give birth. There is available to the author no reliable experience—written, spoken, or traditional—which can

form the foundation for deductions concerning the psychological aspect of labour in the primitive woman of any race whatever. The matter of gaining the approval of a Native chieftain sufficiently to be allowed scope to observe labour amongst the women of his tribe has been considered seriously, but the difficulties are almost insurmountable. Official permission cannot guarantee acceptance of a strange accoucheur, however unobtrusive, by parturients and their mentors.

In spite of this lack of an opportunity to study the primitive parturient, it is possible to state that in the urban Bantu parturient there is present a fortitude and an acceptance of the situation such as is very rarely seen in the European, and hardly ever seen in the latter when cases of dystocia alone are considered. Against this observation must be placed the conviction that in hospital the Native is much more apprehensive than the European woman, and that when anything is amiss the Negro is more affected emotionally, and indeed out of all proportion to what is experienced, in the white woman. No doubt all women have more fear in the maternity hospital than out of it; but in the case of the Negro uterine inertia, for example, occurs in a manner which seems quite unnecessary when judged by an attendant accustomed only to European behaviour. An observation that must be universal is the absence of resolution in the parturient who knows that she has recourse to the accoucheur and his reputed skill. In most primigravidae there appears to be an instinct that a rigid self-denial is being practised if the doctor's aid is not invoked, and this aid is usually visualized as being an operative termination of her travail. In the primitive woman there is no false, and withal evil, premise of this kind. Her tradition dictates what she so simply accepts, that delivery depends entirely on her own efforts. No doubt she is ignorant

of the curse "in sorrow thou shalt bring forth children." But once she finds herself in hospital, primeval independence is swallowed up in complete surrender to the ones with the higher knowledge. And how pathetic is artificial aid to uterine power!

One's early experience with Bantu antenatal cases stultified such judgment as was based on an experience of white women with disproportion. As an example, the case of a girl aged 13 years may be taken. Examination showed the pelvis to be still very small, but without any appreciable distortion. The diagonal conjugate was easily measured and found to be well under $3\frac{1}{2}$ inches. The father of this girl was particularly displeased about her seduction, and his chagrin was aggravated by the advice that a Caesarean section would be necessary. He consented to the compromise that the girl be given a trial labour in the clinic and, if transfer to hospital then became necessary, consideration of this step would be acceptable. It soon became obvious that highly instructive trial labours carried out on the district would be presented to one, because of a strong prejudice against maternity hospitals. The test of labour of the patient of 13 ended in defeat for myself, for labour terminated in undramatic fashion. The infant was alive, weighed 7 lb., and had a biparietal diameter of 9 cm. and occipito-frontal 11.2 cm.

In other cases the patient would be in hospital and fail to respond to drug induction of labour at term. A week or more after even trial labour was judged to be no longer humane, such a case of contracted pelvis would go into labour and deliver spontaneously in 5 or 6 hours of observed labour.

This led to the view that the size of the non-pathological pelvis was hardly ever an absolute factor in deciding in favour of Caesarean section. Provided that contractions are powerful, almost any natural

obstruction can be overcome by the Bantu woman. The more difficult problem now emerges of having to decide how far uterine contraction may be allowed to take its course, for too great action may successfully end labour but kill the foetus. And this last result may be observed in the Bantu.

MATERIAL AND METHODS.

Introductory Note.

In order to become better acquainted with the bony passages as a factor in labour, skeletal material was studied in the Anatomy Department. It was realized that dry female pelvises could only be available in comparatively small numbers, and that thorough study would depend for material on the living subject. This demanded radiographic methods. Experiment, however, demonstrated how unreliable X-ray pelvimetry was, and it became necessary to find the best and most efficient method with a precise knowledge of the range of error involved.

For the present study there is available a practical knowledge of the pelvic capacity of each parturient and the details of her labour. It is thus possible to consider the accomplishment of each woman in giving birth to her child, in order to discover what capacity of the pelvis is compatible with spontaneous delivery.

In reducing this problem to precise values one is guided by a consideration first suggested by Nicholson.⁷ It has been shown that in 500 Bantu newborn the mean area of a cross-section of the head with biparietal and suboccipito-bregmatic diameters as axes (i.e. the fully flexed head) was 68.64 sq. cm. It follows that all planes of a pelvis must have a sufficiently large area to accommodate this largest area of the well flexed head. For the deflexed head a corresponding area of a cross-section with biparietal and occipito-frontal diameters as

axes may be taken. The corresponding mean area in the latter case was 80.64 sq. cm. If it be remembered that during labour the bony pelvis is occupied by structures other than the foetal head, but that moulding makes it possible for the head to occupy most of the available area of any pelvic plane, the interesting question arises as to what is the maximum pelvic contraction that would still allow spontaneous expulsion.

On this point Nicholson⁷ comes to the following conclusion: "It seems then likely that the line below which normal delivery becomes a doubtful proposition should be drawn somewhere about an area of 90 square centimetres." Ince and Young⁸ the other writers who have taken the trouble to express their findings in numbers and thus with greater precision than has been the custom, admit that their series does not contain sufficient evidence to suggest a figure lower than 90 sq. cm. as the limit of the area of the pelvic brim through which normal delivery is likely: they had only 1 woman with a brim area between 84 and 90 sq. cm., and 3 between 90 and 95 sq. cm. They refer to the teaching that the lower limits of probable natural delivery are a conjugata vera of $3\frac{1}{2}$ inches in a flat pelvis and $3\frac{1}{2}$ inches in a generally contracted pelvis. These give approximate areas of 87 sq. cm. for the flat and 78 sq. cm. for the generally contracted pelvis.

If the area of a cross-section of the foetal head is about 70 sq. cm., it would seem impossible for such a head to negotiate pelvic planes that are not above 70 sq. cm. at least. It might be guessed that a pelvic plane of at least 80 sq. cm. would be a requisite for spontaneous delivery. And this corresponds with the traditional belief stated above that in certain cases a true conjugate of $3\frac{1}{4}$ or $3\frac{1}{2}$ inches might permit natural expulsion of the foetus.

The series of Nicholson⁷ and Ince and

Young⁸ totalled about 850 cases, whereas the present Bantu series consists of only 100 primigravidae. A report on the Bantu is, however, justified because of the small pelvis encountered. The 850 English women provided only 3 brim areas below 90 sq. cm. and none below 85 sq. cm. Nicholson⁷ had 4 outlet areas below 80 sq. cm., but minimizes the significance of contraction of this rather mobile portion of the girdle. Ince and Young⁸ fail to discuss their small outlets specifically, and record no outlet areas in their special cases (including Caesarean sections). In the 100 Bantu primigravidae there were 14 areas below 80 sq. cm., 2 of these pelvis having only the outlet area below 80 sq. cm. With a view to investigating levels of contraction that offered insuperable obstruction, the original plan was to consider in retrospect labours that had occurred in women admitted to the gynaecological ward with vesico-vaginal fistula. Of 25 such cases considered here, 14 had pelvic levels below 80 sq. cm. in area. This series contributed little to the study of labour in contracted pelvis. Nevertheless, the present analysis is based on 28 cases with areas below 80 sq. cm., and on this foundation the series bears comparison with the invaluable studies of the workers mentioned above.

Material.

(a) Vesico-vaginal fistula (25 cases).

These patients presented themselves at the gynaecological clinic with fistulae following labour. As ward patients awaiting operation they were X-rayed, and at the same time their histories were checked. On a few occasions all available cases were subjected to X-ray pelvimetry, but there was no conscious selection. A hundred cases could without much difficulty be thus studied radiographically, but there is a great weakness inherent in this material. No skilled obstetrician could allow labour

to proceed sufficiently long to cause a fistula. Therefore, the details of these labours must be inadequate because of the absence of a trained observer. Further, even the duration of the second stage will be unknown, because no trained attendant would allow this stage to be unduly protracted.

(b) Primigravidae from an antenatal clinic (103 cases).

These women were 103 consecutive Bantu primigravidae from the University Antenatal Clinic at Alexandra Township. This township is situated on the outskirts of Johannesburg and has a population of about 80,000. The men and some women are occupied in the city or suburbs, but not on the gold mines; and there are numerous schools and churches in the township which are owned by the inhabitants. There is a well established polyclinic from which *inter alia* a district service is operated. Students are in residence here and attend the clinic, there are several doctors on the permanent staff, and the full-time personnel of the University Department of Obstetrics and Gynaecology conduct the antenatal clinics. Midwives consult the obstetricians concerning cases of abnormal labour, and these are transferred to the Bridgman Memorial Hospital (maternity) when necessary. No instrumental or other complicated deliveries are effected on the district.

The group of primigravidae provided the following material:

Normal labours in women over 19 years of age	45
Normal labours in women under 20 years of age	39
Labour ending in stillbirth not due to labour	3
No record of labour	4
Cases transferred to hospital	12
Total	103

The age incidence of the normal labour group under 20 years of age was:

4 patients were aged	15 years
9	16
6	17
13	18
7	19

(c) Other Bantu material referred to is embodied in a D.Sc. thesis presented to the University of the Witwatersrand and entitled "A Critical Analysis of the Bantu Pelvis with Special Reference to the Female."¹¹

Methods.

(a) The X-ray method of pelvimetry used was described in this journal (Heyns⁹). A further evaluation of the accuracy of the X-ray measurements is presented in Appendix I.

The calculation of areas of brim, cavity, and outlet was checked experimentally in the paper referred to.⁹ The suggestion of considering brim and outlet shapes as ellipses and thence calculating their area came originally from Nicholson.⁷

The measurements sought from radiography were those laid down by Heyns,⁹ and comprise areas of brim and outlet, pelvic brim index, height of symphysis pubis, depth of pelvic basin (lateral and anterior), and size of the pubic arch. These were obtained from two X-ray views, an antero-posterior with pelvic brim horizontal, and the Chassard and Lapine¹⁰ method for the pubic arch. For the antero-posterior view the Potter-Bucky diaphragm was used; for the pubic arch the patient sat leaning well forward on a Lysholm grid.

Radiography was carried out at the Non-European Hospital which is adjacent to the Medical School and where the fistula cases are admitted. All the X-rays were done by the chief radiographer and myself.

(b) One feature of the pubic arch which was considered needs explanation. If the perpendicular distance from the antero-

superior edge of the symphysis pubis to the line representing the intertuberal diameter is great (the mean for 87 cases was 10.25 cm.¹) and the distance between the ischial tuberosities small (mean 11.47 cm.¹), it means that the foetal head has to traverse a greater depth of the pelvis before birth by extension becomes possible. Thus, if an arch is narrow, the uterine power required to drive the head beyond the level of the ischial tuberosities will be proportional to the depth of the anterior part of the pelvis.

This variable might be expressed as an index which, for descriptive purposes, will here be called the *pubic arch index*, and is expressed by $\frac{D.P.B.}{T.O.}$ where D.P.B. repre-

sents the perpendicular distance on the film from top of symphysis to line T.O. which itself is the intertuberal diameter. In 76 cases of spontaneous delivery the index was less than unity in 85.5 per cent of this group. When the index approaches or surpasses unity, the pubic arch becomes unfavourable to labour.

(c) For the sake of analysis, area was the dimension on which chief reliance was placed in assessing

1. the capacity of a pelvis, and
2. the prognosis of labour.

The labour was then reviewed in the light of this value and the fact that the well-flexed Bantu foetal head presents a cross-section of 68.64 sq. cm.

An arbitrary level of 80 sq. cm. for the smallest pelvic plane below which insuperable obstruction may be expected was put to the test. The test was applied to the series of 103 primigravidae that provided 14 such small areas, and to 25 cases of vesico-vaginal fistula in whom labour was obviously associated with severe trauma. Concerning the second group, it was known how small the pelves were from experience in fistula operations, and that such trauma occurred in neglected cases that did not

realise the value of modern obstetrical aid. In many of these cases labour terminates miraculously, and it was thought that a certain limit of pelvic contraction might be established in those women who sustain bladder fistulae.

The pubic arch index was analysed for record purposes. It is probably of greater value in moderate forms of obstruction and dystocia: in this paper severe degrees of obstruction are considered, and the accompanying dystocia, if any, evaluated.

RESULTS.

A. Vesico-vaginal Fistula Patients.

Group I.

Smallest area 50 sq. cm. and over; 4 patients. Pubic arches were not X-rayed in any of the 4 cases. All radiographed in November 1943.

Evelyn (20 years); 92.5 sq. cm.; 1 child in 1940; normal labour.

Eileen (26 years); 92.4 sq. cm.; 1 child, born dead; in labour 4 days; no medical help.

Mary; 91.5 sq. cm. No reliable obstetric history obtained.

Anna (20 years); 91.1 sq. cm.; 1 child, alive; in labour 2 days; no doctor; anthropoid brim.

Group II.

Smallest area 80-90 sq. cm.; 7 patients.

Ida (30 years); 84.1 sq. cm. Pubic arch index under 1. Perfect arch. Para 3; 3rd labour in 1943. Instrumental delivery in a Natal hospital without obvious good reason for the bladder fistula which occurred for the first time after the 3rd labour.

Lephina (19 years); 82.3 sq. cm. Pubic arch index under 1. Perfect arch. Para 2. Last labour in March 1943 when fistula followed a forceps delivery. In labour 5 days and in a Natal hospital for all 5 days.

Nettie (24 years); 87.4 sq. cm. Good pubic arch, perfectly female, index less than 1. Delivered in hospital locally one month ago, August 1944. A primigravida, she was in labour about 30 hours. Difficult high forceps resulted in the stillbirth of a big foetus. Incontinence of urine 11 days after delivery.

Mary M. (27 years); 81.6 sq. cm. Narrow pubic arch with perfectly straight rami (index less than 1). Baby born in a country hos-

pital in August 1943, one year ago. Delivered by a doctor. Incontinence of urine and faeces followed. Labour started at home, and lasted 7 days in all. The baby was "manually removed."

Maria M. (32 years); 80.7 sq. cm. Very long pubic arch; moderate width; rather straight rami; index less than 1. Stillbirth 7 months previously. Labour lasted 7 days. Instruments were not used. During puerperium patient was not well.

Elizabeth Z. (26 years); 85 sq. cm. Long, narrow, pubic arch, rounded, index more than 1. "Seven months" premature labour, Incontinence followed: bladder always empty.

Dora; 87.1 sq. cm. Arch not X-rayed. Reliable obstetric history not obtained.

Group III.

Smallest area 70-80 sq. cm.; 12 patients.

Elizabeth T. (17 years); 76.0 sq. cm. Narrow pubic arch; long, rather straight rami; index over 1. Para 3; last child born 3 weeks ago. Pregnancy, labour and puerperium had all been normal. The patient spoke of a difficult delivery at home, resulting in stillbirth and urinary incontinence. Labour had lasted 1 day but the baby was born without assistance. The 2 other children were stillborn, the first being a very difficult labour.

Harriet (43 years); 79.5 sq. cm. Narrow, straight, extremely long arch with index 1.25. One baby 10 years ago. Born dead.

Katrina (24 years); 79.8 sq. cm.; moderate arch, rounded, index over 1. One labour only—stillbirth. Labour lasted 4 days; no doctor.

Flora (17 years); 77.6 sq. cm. Moderate arch, rounded, index over 1. Symphyseal height 4.3 cm. Para 1. Started leaking urine 13 months ago (February 1943) just after labour. Labour lasted 3 days—stillbirth.

Moetse (31 years); 75.4 sq. cm. Narrow arch, well rounded, index 1. Para 1. Labour 9 months ago (July 1943), lasted 3 days. A doctor delivered the baby after 3 days of labour.

Eva (19 years); 74.3 sq. cm. Narrow, very long arch, straight rami, index 1. Symphyseal height 4 cm. Para 1. No reliable history except that the baby was born dead.

Lena (30 years); 75.2 sq. cm. Long, narrow arch with straight rami; index under 1. Para 3, 2 dead. 2 labours lasted 3 days. Incontinence of urine after and labour.

Selina M. (21 years); 79.0 sq. cm. Wide arch with rather straight rami; index under 1. One pregnancy 2 years ago (1942). Labour lasted 5 days when she was delivered of a large child. No doctor was present, but her mother "pulled the baby out."

Phyllis (19 years); 72.6 sq. cm. No X-ray of arch. Para 1. In labour 4 days, then sent to hospital locally. A senior obstetrician is said to have seen her. The baby was born alive but died after one week.

Julia N. (34 years); 78.5 sq. cm. No X-ray of arch. One child 14 years ago (1929). The patient declares that there was no difficulty, but labour lasted 3 days with strong pains. The baby is said to have been big.

Sarah (28 years); 79.4 sq. cm. No X-ray of arch. Obstetric history not available. Anthropoid brim.

NOTE that in the last 2 cases with almost equal areas of the cavity plane the conjugata vera in Sarah was 10.5 cm. or over 4 inches, but in Julia 8.9 cm. or $3\frac{1}{2}$ inches. The respective brim indices were 109.3 and 79.5. The inadvisability of basing pelvic contraction on the true conjugate diameter is illustrated here, but became obvious to all when Caldwell *et al.*¹¹ called attention to the existence of their anthropoid type pelvis.

Miriam (18 years); 79.5 sq. cm. No X-ray of arch. Para 1. Labour lasted 6 days. Baby born dead in a hospital locally. Anthropoid brim (true conjugate 10.3 cm.).

Group IV.

Smallest area 60-70 sq. cm.; 2 patients.

Sophia (20 years); 69.8 sq. cm. Perfect female pubic arch, index less than unity. Para 1. Baby born one month ago (March 1944). In labour for 3 days, then called a doctor who delivered her with instruments. There may have been a craniotomy.

Area of cavity plane = 69.8 sq. cm.

Area of brim = 74.5 sq. cm.

Area of outlet = 77.9 sq. cm.

Maria (18 years); Cavity 63.8 sq. cm.; brim 69.9 sq. cm. No X-ray of arch. Obstetric history not available.

Discussion of Fistula Patients.

Group I.

Of the 4 cases with areas all over 90, there

was only 1 stillbirth. None of these cases had medical help. No pubic arches were X-rayed. All were primiparae in the twenties. Nothing can be learned from these cases. As the pelves had sufficient capacity for spontaneous labour, malpresentation or malposition or trauma inflicted by the Native attendant must have caused the fistula.

Group II.

Seven patients—6 pubic arches available (Areas 80–90 sq. cm.).

Pubic arches. One arch had the index more than 1, 5 arches had the index less than 1.

This proportion of arch indices is similar to that for the 100 unselected Bantu primigravidae; 3 arches were perfectly female; 1 arch was narrow with perfectly straight rami; 1 arch was very long with rather straight rami, but was of moderate width.

The arch with index greater than unity was long and narrow, but rounded.

(a) The 3 cases with perfect arches had areas of the cavity plane 84.1, 82.3 and 87.4 sq. cm. respectively. In all 3 there is some evidence that a fistula should not have resulted; and even though labour may not have ended spontaneously, had forceps not been applied, there is no proof that bladder damage would have occurred.

All 3 cases were instrumental deliveries in a maternity hospital, two in Natal and one in Johannesburg. In the first case (Ida) there had been two previous labours, and there was no obviously good reason for the fistula which occurred for the first time after the third labour. The second case (Lephina) had had one child before without assistance. Fistula followed a forceps delivery after 5 days of labour, the patient actually having been in hospital for all of the 5 days. The third case (Nettie) was a primigravida delivered of a big still-born foetus after 30 hours of labour. A

difficult high forceps extraction was done, and the patient became incontinent of urine 11 days after delivery. While it is admitted that there was dystocia in these cases, the cause must be sought with the powers or the foetus, not the passages; and the resultant trauma was caused by instruments in two at least of the cases, and possibly by a prolonged second stage in the 5-day labour.

(b) In the next 2 cases aged 27 and 32 years, the cavity area was 81.6 sq. cm. in the first, and the outlet area 80.7 sq. cm. in the second. Both labours lasted 7 days. Both patients were delivered in hospital, but state that the baby was taken away without instruments.

(c) The case with the unfavourable pubic arch (Elizabeth Z.) had a cavity plane area of 85 sq. cm., and a "seven months" premature labour. Incontinence of urine followed due to a vesico-vaginal fistula. It seems probable that the fistula was due to trauma inflicted by some Native attendant. It is not uncommon in some districts to find perineal and vaginal trauma caused by various sharp objects. In Dora, the case with cavity area 87.1 sq. cm., there was no reliable obstetrical history, and the pubic arch was not X-rayed. In the early cases studied, pictures of the brim only were taken.

Of the 7 cases in Group II only the 2 described under (b) throw light on the question of the capacity of pelves which are dangerously small. In 7 days these women were unable to deliver themselves, instruments were not used during delivery, and the areas were the smallest of the group. The areas were as follows:

	(1) Sq. cm.	(2) Sq. cm.
Cavity	81.6	105.0
Inlet	86.6	111.2
Outlet	89.4	80.7

The first pelvis is small in all three planes, the second shows contraction of the outlet plane only. It seems, therefore, that an

area in the region of 80 sq. cm. is dangerously small, and, if there is some deflexion or a posterior position of the vertex, then spontaneous delivery is improbable.

Group III.

Twelve patients; 8 pubic arches available (70-80 sq. cm.).

Pubic arches. Only 2 indices are less than unity; 4 indices are greater than unity and 2 indices are exactly 1.

In these smaller pelvises of Group III, therefore, the anterior height of the pelvis minor tends to be greater than the outlet width (intertuberal diameter). In the 8 cases the depth of the pelvic basin measured laterally is on the average 8.88 cm., which is very close to the corresponding figure (8.77 cm.) found: (1) for 67 Bantu dry female pelvises, and (2) for 87 radiographs of Bantu primigravidae.¹ Three of these eight pelvises had this measurement over 9 cm., viz. 9.3, 9.6 and 9.7 cm.

The intertuberal diameter, however, was diminished and ranged from 8.7 to 10.8 cm., with a mean of 9.8 cm. This figure must be compared with a mean of 10.2 cm. for 67 dry pelvises and 11.47 cm. for 87 radiographs of Bantu primigravidae.¹

The pubic arches may be analysed thus:

	Index
Narrow, long, with straight rami	4 (+ + - 0)
Narrow, well rounded	1 (0)
Moderate width, rounded	2 (+ +)
Wide arch, with rather straight rami	1 (-)

(a) In the first 4 cases the pubic arch index was greater than unity—2 arches being long and narrow with straight rami, and 2 of moderate width and rounded. Three patients were primiparous and one (E.T.) was a 3-para. All 4 women had had stillbirths, E.T. having lost all her infants at birth. None had had medical aid, so that all deliveries were spontaneous, though the duration was 3 days in one and 4 days in another. E.T., with a very unfavourable pelvis, considered that her labours had

been normal, but declared that the first had been very difficult! Two striking features of this case are the resignation, with which this girl had repeated stillbirths due to dystocia, and the observation that it was possible for 2 foetuses to negotiate her small pelvis without gross trauma to the bladder.

(b) The next 2 arches, with index 1, were both narrow, one being well rounded and the other long with straight rami. Both were primiparae, Moetse having been delivered by a doctor and having an intertuberal diameter of 8.7 cm. Eva was known to have had a stillbirth, but Moetse's history was equivocal. It is a matter of honour with these women to be able to claim offspring, and experience has shown that in some cases the claims have to be accepted with reserve.

(c) There follow 2 arches with the favourable quality of possessing indices less than unity. In one case, however, the arch was wide with rather straight rami; and the other possessed the converse characters narrow, long, with straight rami. The patients were a para-3 and a para-1. The former with a cavity plane area of only 75.2 sq. cm. had had one live child, 2 labours lasting 3 days, with urinary incontinence after the second labour. She had, therefore, conceived on the third occasion, in spite of the fistula. The other patient's labour had lasted 5 days. Instrumental delivery was not performed in these cases. From both patients (of whom the second had the wide and in most respects normal female pubic arch) one learns that labour becomes extremely difficult when the smallest pelvic plane has an area below 80 sq. cm. While great uterine power may drive the foetus through such a pelvis, it is observed that these parturients have a great struggle.

(d) In 4 patients the arches had not been studied radiographically. Three were para 1, there being no labour notes for the

fourth. Labours lasted 3, 4 and 6 days. Two of the deliveries occurred in hospital: one was a stillbirth, and in the other an area of 72.6 sq. cm. allowed passage of a live child that survived for a week. The last 2 patients of Group III had cavity plane areas of 79.4 and 79.5 sq. cm.; and both had anthropoid type pelves.

Group IV.

Two patients. One pubic arch available (60-70 sq. cm.).

It is to be noted that the pubic arch in this very small pelvis was perfect in every respect. In these two cases one delivery was instrumental, possibly a craniotomy; the other is not recorded.

Comment.

When these cases are operated upon *per vaginam*, access is the main difficulty. In the majority of cases no cervix can be identified, there is a considerable amount of scar tissue in the vagina which itself often shows extensive loss of tissue, and the upper part of the pubic arch is so narrow as to make the fistula appear inaccessible when first explored. Clinical assessment of the capacity of the pelvis by digital exploration in an average case gives the impression of extreme contraction; and one wonders first how these women conceive when they are so poorly equipped for parturition, and secondly how they contrive to deliver themselves. In the neglected cases that end in spontaneous expulsion of the foetus after several days of strong labour, one feels almost that the foetus must have sloughed away in a macerated condition. Occasionally a parturient sends for help after the end of the second stage, and the infant's head is moulded and compressed beyond recognition. The baby is either born dead or dies in an hour or so.

The 25 cases dealt with above do not contribute anything to precise knowledge

concerning the level below which the capacity of the pelvis becomes inadequate for spontaneous delivery. Several of these women delivered themselves without aid, but with resultant fistulae.

It will be seen that a foetus can be expelled through equally small pelvises without severe recognizable trauma.

TABLE I.

Areas of Small Pelves.

Pelvic plane areas in patients with vesicovaginal fistula. The smallest area is shown, and this is the cavity plane area in all cases except the two marked (o).

60-70	70-80	80-90	Over 90
sq. cm.	sq. cm.	sq. cm.	sq. cm.
63.8	72.6	80.7 (o)	91.1
69.8	74.3	81.6	91.5
	75.2	82.3	92.4
	75.4	84.1	92.5
	76.0	85.0	
	77.6 (o)	87.1	
	78.5	87.4	
	79.0		
	79.4		
	79.5		
	79.5		
	79.8		

Primigravidae with pelvic plane areas below 80 sq. cm.

Brim area	Cavity plane area	Outlet area
sq. cm.	sq. cm.	sq. cm.
66.6	60.0	
75.4	71.7	64.5
69.4	64.7	
74.6	68.6	78.5
76.0	72.0	
104.9	100.0	72.6
81.4	76.1	96.7
81.5	77.0	76.0
91.0	86.5	77.0
83.5	77.8	95.9
83.2	78.0	99.3
85.3	78.8	
83.1	79.4	94.1
84.1	79.4	

100 PRIMIGRAVIDAE.

The group of primigravidae provided the following material.

Normal labour in women over 19 years of age	45
Normal labour in women under 20 years of age	39
Labours ending in stillbirth not due to labour	3
No record of labour	4
Cases transferred to hospital	12
	—
	103

The age incidence of the normal labour group under 20 years of age was:

4 patients were aged 15 years
9 " " " 16 "
6 " " " 17 "
13 " " " 18 "
7 " " " 19 "

Analysis of the distribution of different values of the pubic arch index was as follows:

- (a) Normal labours in the under 20 age group:
- | | |
|-----------------------|-----------------------|
| Index not less than 1 | 4 |
| Index less than 1 | 28 (2 areas under 80) |
- (b) Normal labours in the over 19 age group:
- | | |
|-----------------------|-----------------------|
| Index not less than 1 | 6 (1 area under 80) |
| Index less than 1 | 31 (3 areas under 80) |
- (c) Miscellaneous (macerated foetus, lost cards, et cetera)
- | | |
|-----------------------|-------------------|
| Index not less than 1 | 1 (area under 80) |
| Index less than 1 | 6 |
- (d) Hospital cases.
- | | |
|-----------------------|----------------------|
| Index not less than 1 | 4 (2 areas under 80) |
| Index less than 1 | 7 (1 area under 80) |

The cases delivered at home, therefore, had 11 or 14.5 per cent of pubic arch indices not less than unity. The cases transferred to hospital showed a corresponding figure of 36.4 per cent. This difference is 1.46 times its standard error, and is not significant.

It is not sound to take hospital or assisted

deliveries as a standard for analysing unfavourable features such as "long arch," because a spontaneous labour may have been even more difficult than the former labours.

An analysis on the assumption that 80 sq. cm. was the critical value for the pelvic capacity was based on the smallest area of any pelvic plane. At the outset, therefore, interest was confined to areas below 80 sq. cm.

Age in years

15	No area under 80	Labours all normal
16	3 areas under 80	
17	No area under 80	
18	3 areas under 80	
19	No area under 80	
over 19	8 areas under 80	Labours all spontaneous
	—	
Total	14 areas under 80	

Of the 14 cases, 12 reached term normally and 2 were as follows: (i) Macerated foetus born at full term. R.O.A. Male; (ii) It emerged later that this patient was not pregnant. It is probable that abortion had occurred in early pregnancy.

The most immediate possibility in analysing the primigravidae is to consider: (1) the above 14 examples with area below 80 sq. cm., and (2) the patients transferred to hospital.

The latter group numbered 12, and of these only 3 pelves had minimum areas below 80 sq. cm. It must be emphasized that operative delivery was effected only in hospital. Therefore, 11 low area pelves were associated with spontaneous delivery, while the operative deliveries were 3 Caesarean sections and 2 forceps extractions.

Cases Transferred to Hospital.

I. Seven cases delivered themselves without assistance, and were sent to hospital for

various reasons. Their records are as follows.

A primigravida of 39 years was transferred on account of her age, i.e. as a precautionary measure. She had a capacious pelvis except for the outlet area which was 87.5 sq. cm. Labour was uneventful.

Three patients with adequate pelvises were sent in during labour, but delivered spontaneously.

One patient aged 16, with brim and cavity areas respectively 84.6 and 81 sq. cm., brim index 95, and with angular pubic arch was sent to hospital on account of a blood pressure of 160/120. She was delivered normally on the next day after a second stage lasting 35 minutes, the first stage having been 15½ hours. The infant weighed 7 lb. 5 ozs. The vertex position was diagnosed during labour as L.O.P.

There was one case of uterine inertia. The first stage lasted 63½ hours, the second 70 minutes. The position of the vertex was diagnosed as L.O.P. An infant weighing 7 lb. 7 ozs. was born with an excessively long caput succedaneum, but on discharge was alive and well. The brim area was 92.5 sq. cm., outlet area 80.8 sq. cm., brim index 93.5, and pubo-sacral diameter 10.4 sq. cm.

One spontaneous delivery in hospital ended in a stillbirth, the foetal weight being not recorded. Labour lasted 17½ hours, the second stage 1½ hours. The cavity plane had the smallest area, 82.3 sq. cm., and the brim index was only 88.2.

Of these 7 cases, the first 4 mentioned are of no interest, their admission to hospital resting on causes not relevant to the present inquiry. The last 3 labours, though they terminated spontaneously, exhibit pelvic levels much lower than any found in some 850 English women of the series analysed by Ince and Young⁸ and Nicholson.⁷ No area was below 80 sq. cm. in these 3 Negroes. The labour notes give an impres-

sion of what is accomplished by these primigravid parturients.

II. In this group, significantly different from Group I in that operative measures were here employed during delivery, there are 5 cases. There were 3 Caesarean sections and 2 forceps deliveries. In 3 women areas reached the low level of under 80 sq. cm., the other 2 being a patient who had been subjected to Caesarean section previously, and a forceps extraction. In order to understand more of these women in labour, some details will be recorded concerning all 5 cases.

(i) The indication for the previous Caesarean section was not known, and in the absence of delivery by the natural passages this patient was included in the series of primigravidae. The second section was performed only because of the first, the pelvis not being contracted except at the outlet. Brim area was 95.5 sq. cm., outlet area 83.7 sq. cm., brim index 95.5; intertuberal diameter 10 cm., pubo-sacral diameter 11.5 cm. The operation resulted in mother and infant both being in good condition.

(ii) A girl of 16 years with the following pelvic measurements. Areas (sq. cm.): Cavity 86.5, brim 91, outlet 77. Brim index 89.3. Intertuberal diameter 9.6 cm., pubo-sacral diameter 10.3 cm.

Clinically it was thought that this pelvis had a funnel tendency, and the radiographic confirmation of this diagnosis led to the decision to perform an elective Caesarean section. It will be agreed that trial labour with a severe degree of outlet contraction is inadvisable, for the stage of low mid-forceps extraction is easily reached—but safe retreat after "failed forceps" in such a case is denied. As frequently happens—and it is this factor which affords an opportunity of observing what would otherwise be an inhuman and dangerous experiment

—permission for an elective operation was refused.

The patient was, therefore, given 2 ounces of castor oil on September 22nd, 1944. Labour commenced the same day. Pains were slow at first, then increased, and at 11.30 p.m. occurred regularly. Only a small part of the head had engaged in the brim, and flexion was poor. An hour later (12.30 a.m.) the patient was sent to hospital. Caesarean section was done a few hours later, a living child being obtained. A small ovarian cyst was found at laparotomy.

(iii) This patient showed an extreme degree of pelvic contraction and in addition an obvious lumbodorsal kyphosis. Areas (sq. cm.): Cavity 60, brim 66.6. Brim index 88.2 (conjugate 8.2 cm. and transverse 9.3 cm.). The pubic arch index was 1.14 indicating a very long arch, and the angle was very narrow.

Intertuberal diameter 8.5 cm., interschio-spinal diameter 8.6 cm. Pubo-sacral diameter not available. Caesarean section was performed.

(iv) High forceps delivery in a primigravida aged 25 years. Areas (sq. cm.): Cavity 78, brim 83.2, outlet 99.3. Brim index 81.8 (conjugate 9 cm., transverse 11 cm.). The fore-pelvis at the brim was narrow, almost angular. The pubic arch index was greater than 1, but the arch was well rounded. Intertuberal diameter 9.2 cm., pubo-sacral diameter 12.8 cm., interschio-spinal diameter 9.9 cm.

The patient went into labour on a Sunday. A member of the University staff reported to me that a large amount of meconium was being passed, but that the foetal heart was very satisfactory. The advice was that the case should merely be watched. The patient was sent to hospital at 10 a.m. next day. Unfortunately, the occipito-posterior position of the vertex which was present was not identified, and

thus immediate Caesarean section was not done. Furthermore, it was not until 5 p.m. that one of our junior staff saw the patient. The os was not fully dilated and the greatest circumference of the foetal head had not negotiated the pelvic brim. The patient's pulse was 150 and temperature 102 degrees. Section could not be done and it was decided to wait. On Tuesday morning the staff member was called to perform craniotomy, but he thought that the foetal heart was still present. An extremely difficult high forceps delivery followed and this triumph was crowned by the fact that the baby was alive; but the infant was in a precarious state with violent moulding of the head. The mother recovered soon and left hospital in average time with a live child. This unhappy case is unique in several respects, but the attendant displayed a skill which matched the event.

(v) A patient aged 19 had an anthropoid type pelvis (brim index 105.8) of the following dimensions. Areas (sq. cm.): Cavity 90, brim 94.1, outlet 87.5. The pubic arch index was over 1, the vertical height of the pubic symphysis above the ischial tuberosities being 10.7 cm., a high figure. This indicates a long pelvis anteriorly. Outlet diameters—intertuberal 10.5 cm., interspinal 9.4 cm. The arch was fairly well rounded.

It was observed on district that advance of the head had become arrested, and the patient was persuaded to go to hospital. Forceps delivery resulted in a stillbirth, of which the weight was not recorded. The reason for this outcome is not clear.

A Case that Failed to go to Hospital.

In contrast to the above cases a most remarkable labour occurred in a woman of 27 years who had had a Caesarean section for the first pregnancy. It had been explained that another section would be

absolutely necessary, for the pelvis had been found to have the following dimensions. Areas (sq. cm.): Cavity 71.7, brim 75.4, outlet 64.5. Brim-index 98.9 (conjugate 9.5 cm., transverse 9.6 cm.).

The pubic arch index was less than 1, the anterior depth of the pelvic basin being 9.5 cm., and the lateral depth 8.8 cm. The arch was well rounded. Intertuberal diameter 10.1 cm., inter-spinal diameter 10.4 cm., pubo-sacral diameter 9.1 cm.

The patient sent for help after the baby had been born. There was extensive perineal laceration. The baby was a female weighing $6\frac{1}{2}$ pounds, and the head was moulded into a misshapen mass. The infant died an hour after birth.

The remarkable feature of this case was not the fact that the uterus with an old scar could withstand such an assault, but that it was at all possible for unaided uterine power to drive a foetus through such a small pelvis. The patient had been in labour for about half the night, and accomplished her feat in the absence of a nurse. So excessive was the force required that the baby succumbed, and the character of the labour was readily appreciated by nursing attendants from the extreme moulding of the head.

Cases with Pelves Possessing a Plane with Area Below the Critical Level of 80 sq. cm.

There were 14 cases out of 103 consecutive, unselected primigravidae that had some level of the pelvis with an area below 80 sq. cm. As 3 radiographs of the brim were of too poor quality to measure, it can be said that 14 per cent of this series presented pelves contracted below the arbitrary critical level of 80 sq. cm. This group is more important than the hospital group, of which it includes 3 cases, because operative delivery may be indicated in malpresentation or malposition, and a case may

be transferred to hospital for reasons other than dystocia due to faults in the passages. What is being studied here is first the capacity of the Bantu pelvis and second, and more important, the achievement of the woman in overcoming whatever resistance proves to be present. An impression of the efficiency of the powers will be gained from these two factors. Faults in the passengers are irrelevant to the present investigation, except that indirect features such as abnormal birth-weight may call for comment.

No girls aged 15, 17 and 19 years had pelves of the size now under consideration.

Girls aged 16 years. Three cases.

1. Caesarean section. Described as Case ii under II of the hospital cases.

2. A school girl who was disgruntled at becoming pregnant. This patient, seen 2 years ago for radiography, has made frequent appearances in my ward and seems to be a schizophrenic. Areas (sq. cm.): Cavity 100, brim 104.9, outlet 72.6. Inter-ischio-spinal diameter 8.4 cm., pubo-sacral 11 cm.

Antenatal attention was given by me personally until very near term. The patient then disappeared for several months, and on her return pretended that she had never been pregnant. She had no doubt destroyed the baby, but appeared to be none the worse for any of her experiences. A year later I recognised the patient in my ward, this time under an assumed name. When I mentioned her full Native name, she confessed. It must be presumed that labour had been unassisted.

3. Areas (sq. cm.): Cavity 68.6, brim 74.6, outlet 78.5. Pubic arch—index less than 1, interspinal diameter 11.1 cm., intertuberal 12.6 cm.; pubo-sacral 10.4 cm. The arch is wide and very well rounded. Brim-index 92.8 (conjugate 9 cm., transverse 9.7 cm.). A normal labour ended in the stillbirth of a female weighing $7\frac{1}{2}$ pounds.

Girls aged 18 years. Three cases.

4. Areas (sq. cm.): Cavity 64.7, brim 69.4. Pubic arch—index less than 1, interspinal diameter 8.5 cm., intertuberal 10.5 cm., pubo-sacral diameter not measured. Arch rounded. Brim-index 98.1 (conjugate 9.0 cm., transverse 9.2 cm.). The baby, weighing 6 pounds, was born before arrival of the nurse.

5. Areas (sq. cm.): Cavity 79.4, brim 84.1. Pubic arch—index less than 1, interspinal diameter 11.2 cm., intertuberal 12.2 cm., pubo-sacral diameter not measured. Arch rounded. Brim-index 88.2 (conjugate 9.4 cm., transverse 10.7 cm.). A macerated foetus was born at full term. Male. R.O.A.

6. This patient came for X-ray as an early pregnancy. Vaginal haemorrhage started while she waited in the X-ray department. A note on my X-ray card refers to her having pronounced interstitial keratitis. The patient reported later at the antenatal clinic and an entry was made that she was not pregnant. It is possible that this patient aborted; but in spite of the absence of parturition, pelvic measurements are recorded for the sake of analysis.

Areas (sq. cm.): Cavity 72, brim 76. Pubic arch—index more than 1, interspinal diameter 10.9 cm., intertuberal 9.9 cm., no pubo-sacral diameter available. The arch is very narrow. Pronounced convergence of this pelvis—dangerous outlet. Brim-index 84.6 (conjugate 8.8 cm., transverse 10.4 cm.).

Women aged 20 years and more. Four cases.

7. This patient was described under II of the hospital cases as "a case that failed to go to hospital". Previous Caesarean section and, on this occasion, she delivered herself before the nurse was called. The foetus weighed $6\frac{1}{2}$ pounds and died an hour after birth.

8. The patient described as (iv) under II of the hospital cases. High forceps delivery. Live child.

9. Areas (sq. cm.): Cavity 77.8, brim 83.5, outlet 95.9. Pubic arch—index less than 1, interspinal diameter 10.8 cm., intertuberal 12.4 cm., pubo-sacral 11.3 cm. Arch rounded. Brim-index 93.2 (conjugate 9.6 cm., transverse 10.3 cm.). Normal delivery of a male weighing 7 pounds. The infant was asphyxiated but responded to treatment.

10. Areas (sq. cm.): Cavity 79.4, brim 83.1, outlet 94.1. Pubic arch—index less than 1, interspinal diameter 9.5 cm., intertuberal 11 cm., pubo-sacral 12.6. Arch very well rounded. Brim-index 107.3 (conjugate 10.4 cm., transverse 9.7 cm.).

It is to be noted that an anthropoid type pelvis in this case had an area of the upper planes as low as 80 sq. cm. It has been our experience with skeletal material that the anthropoid type only rarely possesses small dimensions.

A full-time female was born spontaneously, weighing 5 pounds 14 ounces. The patient had slight pains for 2 days, after which she was obviously in labour. The membranes ruptured early next morning, and the baby was born at 9.5 a.m.

Women of Unknown Age. Four cases.

It is not uncommon for a Bantu woman to be ignorant of her age.

11. This patient was described as (iii) under II of the hospital cases. Caesarean section. Area of cavity plane was only 60 sq. cm.

12. Areas (sq. cm.): Cavity 76.1, brim 81.4, outlet 96.7. Pubic arch—index less than 1, interspinal diameter 10.7 cm., intertuberal 11.9 cm., pubo-sacral 11.5 cm. Arch rounded. Brim-index 85.6 (conjugate 9.1 cm., transverse 10.6 cm.). Probably the platypelloid type (Caldwell *et al*).

Normal delivery of a live baby weighing 6½ pounds.

13. Areas (sq. cm.): Cavity 77, brim 81.5, outlet 76.0. Pubic arch—not radiographed. Interspinal diameter 9.2 cm., pubo-sacral 10.5 cm. Digital palpation showed that the arch was wide. Brim—index 102.1 (conjugate 10.0 cm., transverse 9.8 cm.). The patient was delivered of a female weighing nearly 7 pounds. L.O.A. The baby was asphyxiated but survived.

14. Areas (sq. cm.): Cavity 78.8, brim 85.3. Pubic arch—index more than 1, interspinal diameter 10.0 cm., intertuberal 10.2 cm., no pubo-sacral diameter available. The arch tended to be angular. Brim—index 79.9 (conjugate 8.95 cm., transverse 11.22 cm.). Android type brim. Normal delivery of a live child weighing 7 pounds.

Notes on Spontaneous Labours Not Discussed Under the Hospital or Under 80 sq. cm. Group.

There were 34 patients aged 15 to 19 years, and 40 patients of 20 years and over. These cases were delivered on the district and had pelvic areas which were all over 80 sq. cm.

J.Z. (age 16). Zulu. Normal labour. Live child weighing 8½ pounds. Areas (sq. cm.): Cavity 91.3, brim 97.9, outlet 89.6. Pains started during the night. Help sent for at 5.55 a.m. Membranes ruptured during the night (time unknown). Male infant born at 10.45 a.m. Placenta and membranes expelled complete at 11.5 a.m. Blood loss normal. Uterus firmly contracted.

J.N. (aged 15). Zulu. Normal labour. Areas (sq. cm.): Cavity 80.5, brim 86.5, conjugata vera 9.6 cm, brim index 89.7. Labour lasted 20 hours; 2nd degree laceration; birth-weight not recorded.

Three patients had live babies weighing 10 pounds. Areas of cavity plane were respectively 116.8, 99.5, and 95.6 sq. cm. The outlets were all adequate. The patient with the smallest pelvis was one of our nurses (I.M.), the areas in sq. cm. being: cavity 95.6, brim 99.5, outlet 99.0.

CONCLUSIONS.

The two English series of parturients previously studied, those by Nicholson⁷ and Ince and Young,⁸ provide the only analyses known to us which aim at a precise evaluation of pelvic capacity as a factor in parturition. Whereas these investigators did invaluable work in presenting radiographic data in large numbers of gravid women, they had the misfortune to deal

	15-19 years		Over 19 years	
	No.	Per cent	No.	Per cent
Birth-weight 8-9 pounds	8	23.5	11	27.5
9-10 pounds	0		0	
10 pounds	0		3	7.5
Born before arrival { Total	11	32.4	8	20.0
of attendant { Pelvic area under 90 sq. cm.	3	8.8	3	7.5
Areas between 80 and 90 sq. cm.	13	38.2	11	27.5
Breech presentation*	1		0	
Stillbirths	0		0	

* This breech presentation was the only one in the total series. The baby weighed 4 pounds and was probably premature.

A few labours will be described to illustrate further what is experienced in these cases.

with material in which there was an absence of that degree of pelvic capacity which causes dystocia *per se*. It is recog-

nized that these series derive from London and English rural populations. In the industrial English Midlands and Scotland small pelves and their effect on labour can no doubt be more profitably investigated, but in these areas the degree of rickets would complicate research into the effect of morphological types of pelvis on normal parturition. An opportunity of studying labour in the non-pathological small pelvis has been offered in the case of the South African Negro or Bantu. Rickets in this racial group, though not negligible, does not often lead to gross distortion of the pelvis. In this respect the Bantu pelvis is comparable with that existing in London and any other area in which the girdle has undergone uninterrupted development.

It has been shown, first of all, that the size of the new-born Bantu baby is in no respect different from that found in higher races. The mean birth-weight of nearly 7 pounds⁹ is below the average for white races, but this is probably due to less subcutaneous fat and cannot exert great influence on the normality of parturition. These facts concerning the Bantu are fundamental.

It has been shown, secondly, that the necessity for operative assistance in the Bantu parturient is exceptional. Instrumental delivery including Caesarean section was called for in only 5 out of 103 cases; a spontaneous delivery was accomplished in 95 per cent of the primigravidae, in spite of the fact that 14 pelves had some plane less than 80 sq. cm. in area and 24 had a corresponding area between 80 and 90 sq. cm. In 850 of the English women mentioned there were only 3 pelves with brim areas below 90 sq. cm., all being above 85 sq. cm. No further argument is required to confirm the claim that the South African Negro parturient is superior functionally to her European counterpart. What is the reason for this ability in the Bantu to expel a foetus

through a smaller bony canal than is usual in the European?

It must be admitted that there is no incalculable virtue inherent in the Bantu woman. Successful labour depends on three main factors: the passenger which, for purposes of the present inquiry, is of a constant nature; the bony passages which exhibit pronounced contraction more frequently in the Bantu; and the powers of expulsion. It is the quality of the powers that offers an explanation. There can be no doubt that fundamentally the white woman can accomplish as much as the Bantu. Concerning white women, however, it is generally admitted that faults in the powers are responsible for a great majority of all the complications met with in abnormal labour. It is submitted that in the European there is an unfavourable emotional background which has an inhibitory effect on efficient uterine action. Where in any individual parturient there is emotional stability supported by an unwavering resolution to push through with the task of spontaneous delivery, and where the realisation that obstetric aid is readily available is not over emphasized or too great dependence on such aid is absent, the achievement of the Bantu woman may always be equalled. The question of the magnitude of uterine force that can safely be allowed is not relevant to the present argument, and indeed rarely enters into considerations of parturition in the white woman.

There is evidence in the cases quoted that the Bantu woman in many instances does not even entertain the idea that modern trained assistance is available. Thus a woman with a very small pelvis had three consecutive stillbirths without appealing for aid. This is a disadvantage, but her tradition must be compared with that of the European who considers that she has engaged an obstetrician who knows more

about parturition than she does, and whom she intends giving abundant opportunity of exercising his ability. At the risk of being accused of begging the question, it is to be pointed out that the Bantu experience further strengthens the concept that faults in the powers are responsible for most dystocias, for simple dystocia due to contracted bony passages can almost be eliminated by fostering the will in a parturient to deliver herself.

How does a normal-sized head with a cross-section of 70 sq. cm. succeed in passing across pelvic planes which have an area below 70 sq. cm? This is obviously due to moulding of the foetal head. If a spherical lump of plasticine of diameter 2 inches is to be forced through a ring of diameter 1 inch, the feat may be accomplished by rolling the lump of plasticine between the fingers and making it pass end-on through the ring. This is in effect what occurs in the case of the foetal head. The illustration is based on theoretical grounds, but it is now seen that with powerful contractions and extreme moulding, a flexed head with a certain cross-section area may negotiate a girdle of smaller area.

The South African Negro pelvis is smaller than that of the white woman, but the foetal head is, nevertheless, of comparable size. Perin¹² reports external measurements from 2,033 indigenes from Kimvula, Belgian Congo. The external conjugate average of 17.5 cm. suggests small pelves, and Perin believes that these natives are a degenerating race, no female exceeding a height of 1 metre 50 cm. However, the neonatal cephalic measurements show the head to be only slightly smaller than that of the Bantu, the biparietal and suboccipito-bregmatic diameters both being just under 9 cm. Similarly Pan's Hindu pelvis¹³ had a mean calculated brim area of 95.1 sq. cm. which is equal to the smallest area (95) of Ince and Young's range. The only measure-

ment of the Hindu babies given is the mean birth-weight of 5 pounds 6½ ounces in 100 observations. Leicester's¹⁴ figures for Indian new born head measurements indicate that the Indian heads (e.g. Bengali) are considerably smaller than those of the Bantu. It seems as though inferiority of the female adult skeleton in the two African races (*vide* the pelvis) is not matched by smaller dimensions of the foetal skeleton. In the Hindu it is possible that the purdah woman produces a species of purdah child of which even the growth has been inhibited by fantastic environmental shortcomings during pregnancy.

The Africans, on the other hand, are relatively vigorous, independent, and quite undisciplined. It may be suggested that the smallness of the pelvis is due to malnutrition during the second and perhaps third year of life. This is possibly an epoch during ontogenetic development when the future adult pelvis is foreshadowed; and lack of calcium, phosphorus, and vitamins at this time may prejudice bone growth sufficiently to produce the smallish pelvis of the Bantu. The young child is unable to fend for itself and at this stage is completely dependent for nutrition on what is directly given to it. The conditions of life can be gauged from the fact that even in areas where the white man exercises his influence the infantile mortality is 500 per thousand and sometimes more. The mortality is approximately known for relatively small communities, and even here there is difficulty in arriving at the figures; but it is generally agreed that the mortality for the whole country must be about 500 per thousand.

The reason for good skeletal development in the Bantu foetus and in the foetal head of Perin's African race may be explained on the assumption that during pregnancy the mother, with her small pelvis now fully crystallized, looks after herself with aggres-

sive acquisitiveness and feeds on the best that is available. This advantage to the foetus, strengthened possibly by an inherent hardness for the skeleton to grow in utero even under unfavourable conditions, produces a head which is as large as that found at birth in better favoured communities (e.g. European). Thus a normal-sized passenger has to negotiate obstructed passages. Where the disproportion is exaggerated the mother has still to depend on Nature for her delivery, and she believes that death in childbirth is the alternative to success.

Concerning the arresting data presented for Bantu parturition, a final point requires discussion. It may be felt that the contents of this paper are acceptable provided that the X-ray measurements are reliable. Experimental work has shown the value of the method used (Heyns⁹); and in addition the data of Appendix I confirm what was suggested tentatively at first. It may be accepted that the area of the plane of the cavity is, as it is shown on the X-ray film, the narrowest part of the girdle proper. There can be very little error about the area calculated in this case: the only mistake made by radiologists was to take this shadow to represent the outline of the brim. The brim can never be shown radiographically, whatever method is used. The outlet area is uncertain because the pubo-sacral diameter can never be measured accurately; but the outlet plane is not rigid, and its ability to increase in area detracts from the value of outlet areas. Most of the small areas shown in this paper have been the reliable "cavity" areas. The pubic arch measurements may be accepted as accurate.

The appendix also indicates that the method of measuring the conjugata vera gives a mean increase over the true conjugate of 0.3 cm. It is to be noted, therefore, that the small conjugates referred to for

some pelves (i.e. below 9 cm.) are in fact even shorter than recorded.

SUMMARY.

1. X-ray pelvimetry has been carried out on 103 primigravidae and 25 cases of postnatal vesico-vaginal fistula. Parturition has been assessed on the basis of the areas of the planes of the brim, cavity, and outlet of the pelvis.

2. The fistula cases did not provide as much information as was expected concerning the level of pelvic contraction below which spontaneous delivery becomes improbable. This was due to the fact that bladder trauma was sustained in the absence of a trained observer, and dystocia may have been due to factors other than small pelvis.

3. (a) In the series of primigravidae there were 14 pelves that had a plane area below 80 sq. cm., and 24 pelves with areas 80 to 90 sq. cm. The greatest cross-section of the well flexed Bantu foetal head has an area of 68.64 sq. cm. and it seemed reasonable to suppose that a pelvic area of 80 sq. cm. would be required for passage of the well flexed head.

(b) Twelve cases were sent to hospital, but only 5 had instrumental deliveries: 3 Caesarean sections and 2 forceps extractions.

4. The fact that Bantu women have delivered spontaneously with pelvic areas below 70 sq. cm. was unexpected. This and other features of the cases considered have led to the conclusion that the South African Negro as a parturient is greatly superior to the white woman. It has been suggested that the difference lies in the powers (uterine and other muscular action) which are used to the full in the Negro, but suffer a partial inhibition in the white woman.

5. Of 103 single pregnancies in primigravidae, 8 resulted in loss of the foetus.

There were 1 abortion, 3 macerated foetuses, 2 stillbirths in hospital; and on district 1 stillbirth and 1 infantile death an hour after birth.

ACKNOWLEDGMENTS.

I wish to express my thanks to two members of my staff, Drs. N. E. C. de la Hunt and S. Shippel, for their co-operation from the antenatal clinic end. All expenses connected with the radiological work were defrayed by a grant from the National Research Council of South Africa.

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APPENDIX I.

Further Results to Test the Accuracy of the X-ray Method Described Previously.

In addition to the experiments in X-ray pelvimetry discussed by Heyns,⁹ 20 dry Bantu female pelvises were radiographed with the brim horizontal. The purpose of this was to find the accuracy of the modifications suggested for measuring the lengths of the inter-ischio-spinal diameter and the transverse of the brim, the area of the brim, and the brim index. The true measurements of these diameters and the planimeter area of the brims were known from precise measurement on the dried pelvis.

1. The greatest error for the interspinal diameter was -2.4 mm. in one case, the majority of errors being under 1 mm., and a few 1 to 2 mm. It was suggested previously that the error would rarely be more than 1 mm. The mean error was 0.0995 cm.: in 1 there was no error, in 5 there was a plus error, and in 14 a minus error.

2. For the brim transverse diameter, it was found in the 20 specimens that the average error was -0.589 cm. It was pointed out previously that the true brim transverse was never shown on the X-ray film, and that the outline of the brim on the film always represented a level of the pelvis near the cavity plane. It was suggested that the X-ray transverse diameter was about 7.5 mm. shorter than the brim transverse.

3. The modified true conjugate suggested showed a mean increase for 20 pelvises of +0.289 cm. over the actual true conjugate. Against this there is a loss of 0.589 cm. for the transverse as explained in 2.

4. *Area of brim.* On the average (20 pelvises) the calculated X-ray brim area was 6.39 sq. cm. less than the true planimeter area. For these pelvises the mean planimeter area was 112.655 sq. cm. Therefore,

the mean percentage error of the calculated X-ray brim area is - 5.67.

5. *Area of cavity.* Here the X-ray area was less than the area calculated from bone measurements in half the cases, and more in half. The minus errors showed a greater total area. The mean error of - 1.5 sq. cm. is much smaller than the error for the brim.

6. *Brim index.* It will be observed that the brim index is in truth a "cavity"

index. The conjugate diameter is on the average 3 mm. more than it should be, and the transverse 6 mm. less. Therefore, the index obtained must be a little higher than Turner's index. This suggests that a higher index will be found than is in fact the case. Thus in 65 dry pelvis the index was 90.4 ± 2 with a range of 69.6 - 104.4. In 100 pregnant women the mean index was 93.6 ± 0.72 with range 79.7 - 121.2.

APPENDIX II.

Analysis of the dimensions of Bantu pelvis referred to in this paper. Comparative figures have been given for the Bantu male and English urban and rural populations

Pelvic dimensions.	Origin	No. of observations	Mean	Standard deviation	Coeff. of variation per cent	Range
Conjugata vera (cm.)	B. Male	100	10.33 ± 0.11	1.06	10.2	7.9 - 12.8
	B. Female	66	10.76 ± 0.10	0.80	7.6	9.1 - 12.6
	B. Antenatal	100	10.59 ± 0.08	0.81	7.7	8.2 - 12.5
	B. Stereometric method	25	11.01			
	Rural E.	350	11.64	1.05	9.0	8.35 - 14.35
	London E.	509	11.83 ± 0.04	1.0	8.5	8.7 - 15.0
Transverse of brim (cm.)	B. Male	100	11.26 ± 0.08	0.80	7.1	9.5 - 13.3
	B. Female	67	11.96 ± 0.10	0.80	6.5	9.8 - 13.8
	B. Antenatal	100	11.34 ± 0.08	0.78	6.9	9.15 - 13.0
	B. Stereometric method	25	12.07			
	Rural E.	350	13.23	0.76	5.8	11.0 - 16.0
	London E.	509	13.06 ± 0.03	0.7	5.4	10.9 - 15.4
Inter-ischio-spinal diameter (cm.)	B. Male	100	8.05 ± 0.07	0.72	8.9	6.2 - 9.7
	B. Female	66	9.70 ± 0.13	1.00	10.3	6.5 - 12.4
	B. Antenatal	100	10.47 ± 0.09	0.93	8.9	7.45 - 12.58
	B. Stereometric method	24	10.03			
	Rural E.	250	10.54	0.77	7.3	8.25 - 12.75
	London E.	376	9.95 ± 0.04	0.71	7.1	7.5 - 11.5
True area of inlet (sq. cm.) by planimeter	B. Male	100	99.35 ± 1.32	13.16	13.2	70.4 - 140.2
	B. Female	51	113.38 ± 1.31	9.29	8.2	94.0 - 135.8
Calculated area of inlet (sq. cm.)	B. Female	66	101.23 ± 1.25	10.17	10.1	74.75 - 126.8
	B. Antenatal	100	99.33 ± 1.21	12.09	12.2	66.6 - 127.6
	B. Stereometric method	25	113.04			
	Rural E.	350	121.0	12.9	10.7	86.0 - 162.0
Area of plane cavity (sq. cm.)	London E.	375	126.80 ± 0.66	12.8	10.1	95.0 - 165.0
	B. Male	100	89.56 ± 1.22	12.24	13.7	58.8 - 113.2
	B. Female	67	111.78 ± 2.78	11.40	10.2	85.2 - 135.2
	B. Antenatal	100	93.75 ± 1.26	12.58	13.4	60.0 - 121.9
	B. Stereometric method	25	104.82			

Pelvic dimensions.	Origin	No. of observations	Mean	Standard deviation	Coeff. of variation per cent	Range
Area of outlet (sq. cm.)	B. Male	100	63.27 \pm 0.82	8.24	13.0	43.8 - 82.4
	B. Female	65	88.80 \pm 1.52	12.30	13.8	58.1 - 116.9
	B. Antenatal	65	100.12 \pm 1.88	15.12	15.1	64.5 - 131.0
	B. Stereometric method	20	101.95			
	Rural E.	250	106.7	11.90	11.2	70.0 - 142.0
	London E.	376	93.70 \pm 0.54	10.40	11.1	65.0 - 120.0
Pubosacral diameter (cm.)	B. Male	100	10.05 \pm 0.07	0.73	7.3	8.3 - 11.7
	B. Female	66	11.65 \pm 0.10	0.80	6.9	10.0 - 13.5
	B. Antenatal	65	12.20 \pm 0.17	1.33	10.9	9.1 - 15.7
	B. Stereometric method	21	12.90			
	Rural E.	250	13.01	0.96	7.4	10.3 - 16.0
	London E.	376	11.97 \pm 0.04	0.86	7.2	9.5 - 14.5
Intertuberal diameter (cm.)	B. Male	100	8.13 \pm 0.11	1.12	13.8	5.5 - 10.3
	B. Female	67	10.20 \pm 0.16	1.30	12.6	6.6 - 13.2
	B. Antenatal	87	11.47 \pm 0.12	1.15	10.0	8.5 - 14.0
	B. Stereometric method	21	10.76			
	London E.	474	10.90 \pm 0.03	0.70	6.4	8.6 - 13.3
Lateral depth of pelvic basin (cm.)	B. Male L	100	9.31 \pm 0.05	0.55	5.9	7.7 - 10.5
	B. Male R.	100	9.27 \pm 0.05	0.55	5.9	7.7 - 10.5
	B. Female L	67	8.75 \pm 0.06	0.51	5.9	7.9 - 10.9
	B. Female R	67	8.77 \pm 0.07	0.56	6.3	7.9 - 11.1
	B. Antenatal	87	8.77 \pm 0.06	0.58	6.6	7.6 - 10.2
	B. Stereometric method	21	7.57			
Anterior depth of pelvic basin (cm.)	B. Antenatal	87	10.25 \pm 0.07	0.66	6.4	8.5 - 12.0
	B. Stereometric method	21	9.87			
Height of symphysis pubis (cm.)	B. Male	100	3.58 \pm 0.03	0.28	7.8	2.8 - 4.4
	B. Female	66	3.45 \pm 0.04	0.30	9.7	2.7 - 4.5
	B. Antenatal	87	3.27 \pm 0.04	0.40	12.2	2.5 - 4.2
	B. Stereometric method	19	2.96			
Pelvic brim index	B. Male	100	91.56 \pm 0.91	9.11	9.9	70.2 - 117.0
	B. Female	65	90.35 \pm 1.02	8.20	9.1	69.6 - 104.4
	B. Antenatal	100	93.60 \pm 0.72	7.20	7.7	79.7 - 121.2
	B. Stereometric method	25	91.27			
	Rural E.	350	88.3	9.40	10.7	65.5 - 113.5
	London E.	509	90.80 \pm 0.36	8.20	9.1	64.0 - 115.0

B=Bantu L=Left R=Right E=English

- NOTE: (1) The 100 males and 65 to 67 females are from skeletal material.
 (2) The antenatal cases derive from the series described in this paper. X-ray pelvimetry was employed.
 (3) The stereometric method was used as a variation to check the other X-ray data.
 (4) The two English series are taken from Nicholson's report on a rural population, and Ince and Young's "London Women."
 (5) Diophtographic tracings were made of the brims of the dry pelves and the precise areas found with a planimeter.

The Blood in Pregnancy

PART I. THE HAEMOGLOBIN LEVEL.

BY

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INTRODUCTION.

A BRIEF reference has been made in a previous paper¹ to the haemoglobin levels of pregnant women in 1944, and it was shown that the levels were higher than were those of a series of women examined in 1942.² In this paper the results obtained in the 2 series are considered in greater detail and an attempt made to discover what are the changes in the haemoglobin level which occur in healthy women during pregnancy.

In 1945 the Committee on Haemoglobin Surveys of the Medical Research Council published their report.³ This includes a review of previous work on haemoglobin levels during pregnancy which will not be dealt with in detail here. But out of the considerable volume of published work on the subject the following points emerge and will be considered in this paper.

1. The haemoglobin level tends to fall during pregnancy. Whether this tendency is normal or is due to a failure to meet the increased demands of pregnancy is not certain. In the last month of pregnancy a rise in haemoglobin level may occur.

2. Age may affect the haemoglobin level.

3. Parity may influence the haemoglobin level.

DETAILS OF THE INVESTIGATION.

The women investigated were all from one Edinburgh antenatal clinic. This is a hospital clinic and women attend from the surrounding country as well as from the town. The economic standing of the women was good.

The first investigation was carried out in the summer of 1942 when 279 women were seen, 165 primiparae and 114 multiparae. Only one estimation was carried out on each woman. The ages of the women varied from 17 to 41. The second investigation was made throughout 1944. One hundred and eighty women were seen, 107 primiparae and 73 multiparae. Ninety-two of the women this time were seen more than once, so that in their case individual changes in haemoglobin level could be recorded. The number of cases investigated in each trimester of pregnancy is shown in Table I. Only one value was recorded in each trimester for any given woman, with the exception of the third trimester, when values after the 36th week were recorded separately. The ages of the women varied from 17 to 40.

The haemoglobin estimations were made on capillary blood obtained by finger prick.

THE BLOOD IN PREGNANCY

The Haldane haemoglobinometer, standardized by the National Physical Laboratory, was used and the standard conditions

observed in the early weeks being similar to those in the later weeks.

It was, however, found that the haemo-

TABLE I.
The Numbers of Pregnant Women Investigated.

First trimester 7-13 weeks	Second trimester 14-26 weeks	Third trimester 27-36 weeks 37-40 weeks		Total
1942 First tests 50	115	114		279
1944 First tests 66	86	24	4	180
Repeats —	24	68	39	131
66		92		43
110		107		311

recommended by the Haemoglobin Survey Committee were observed.

RESULTS.

1. *Changes in the Haemoglobin Levels of Individual Women, 1944.*

Eighty-six of the 92 women were seen twice or more between the 7th and 36th weeks of pregnancy, and the difference between the first and last tests was recorded. Twenty-four of these women and 6 others were seen twice in the third trimester, the second time in the last 4 weeks, and the difference between these tests was recorded. To eliminate the effect of variations in the time between tests the results were calculated and are given as the mean change in haemoglobin in a lunar month (4 weeks).

(a) *7th to 36th week.*

A rise in haemoglobin level occurred in 10 of the 86 women. Three women showed no change and 73 a fall. The mean change of all women was 2.5 per cent Hb. per lunar month. The fall was constant in rate throughout pregnancy, the changes

globin level of the older women fell more rapidly than did that of the younger ones. In Table II are shown the mean falls in different age groups, and it will be seen that the rate of fall increased steadily till the age of 35. In the final small group of women of 35 and over the variations were large and the mean probably not a true one.

Since the relation between age and rate of fall in haemoglobin level was linear it was possible to find a regression coefficient, by the method of least squares, relating the change in haemoglobin per lunar month to age in years. This was found to be -0.11 , with a standard error of 0.050 . When the method was applied to test the significance of this result, it was found that $t = 2.24$ and $p = < 0.05$. In other words, the probability of an increased fall with increasing age being due to chance was less than 5 in 100.

The regression coefficient also showed the extent to which age affected the change in haemoglobin level in this series of women. The coefficient of 0.11 meant that with every year of increasing age the percentage haemoglobin fell another 0.11 per month. Since the mean centre of the series was a

fall of -2.5 per cent Hb. at age 26.9 years, it could be calculated that the expected monthly falls were 1.7 per cent Hb. at 20 years, 2.25 per cent Hb. at 25 years, 2.8 per cent Hb. at 30 years and 3.35 per cent Hb. at 35 years.

The multiparous women at first sight appeared to show a more rapid fall than the primiparae (Table II). Thus while 60

mean change of all the women was -0.4 per cent Hb. per lunar month. Their mean age was 27 years.

Again it was found that the age could be correlated with the change found, but in contradistinction to the result in the earlier months, it was now found that while the younger women continued to show a fall in haemoglobin level the older ones did not

TABLE II.

The Changes in Haemoglobin Level Occurring in Pregnant Women of Different Ages, 1944.

Age, years	Mean change in Hb. per cent per lunar month.			
	Primiparae	Multiparae	All degrees of parity	St. dev.
17-19	-0.75 (8)	—	-0.75 (8)	1.85
20-24	-1.6 (21)	-2.6 (4)	-1.8 (25)	2.3
25-29	-3.0 (20)	-2.05 (6)	-2.8 (26)	2.15
30-34	-3.9 (8)	-3.8 (6)	-3.8 (14)	2.5
35-40	+0.9 (3)	-3.7 (10)	-2.5 (13)	3.5
All ages, mean 26.9	-2.15 (60)	-3.2 (26)	-2.5 (86)	2.6*

* Variation for age allowed for.

Numbers of women in parenthesis.

primiparae fell a mean of 2.15 per cent Hb. per month, the 26 multiparae fell a mean of 3.2 per cent Hb. When their ages were considered it was found that the primiparae had a mean age of 23.4 years, at which the expected fall was 2.1 per cent Hb. per month, while the multiparae had a mean age of 31.2 years at which the expected fall was 3 per cent Hb. per month. The greater fall of the multiparae was therefore due to their greater age.

(b) 37th to 40th weeks.

Of the 30 women who were seen twice in the 3rd trimester, the second time in the final month, 10 showed a rise in haemoglobin level, 7 no change and 13 a fall. The

show any change or a rise. The regression coefficient of change in haemoglobin percentage on age was +0.40 (standard error 0.17, $t = 2.31$, $p = <0.05$). In this series the effect of age was thus again significant. With a mean centre of -0.4 per cent Hb. at age 27 years, it was such that the expected change per lunar month was -3.2 per cent Hb. at 20 years, -1.2 per cent Hb. at 25 years, +0.8 per cent Hb. at 30 years and +2.8 per cent Hb. at 35 years.

2. The Mean Haemoglobin Levels of Pregnant Women, 1944.

While treatment of the results in the above manner is the most accurate method for determining whether changes in haemo-

globin level occur in pregnancy, the numbers seen were not large enough to give figures which could be applied more widely. In this part, therefore, the numbers have been increased by including the results obtained from a further 88 women who were seen once only. In the case of the women seen several times, when possible, one value was recorded in the first and one in the second trimester, one in the third trimester before the 36th week and one after the 36th week. In all 311 observations were made on 180 women—88 women being

(a) 7th to 36th weeks.

The haemoglobin level fell throughout this period—the mean value of the 66 estimations made in the first trimester was 87.8 per cent Hb.—that of the 110 in the second trimester 85.0 per cent Hb.—and that of the 92 in the first part of the third trimester 78.2 per cent Hb.

The effect of age in this series was best seen in the third trimester, by which time the greater fall of the older women had brought their haemoglobin levels to figures well below those of the younger ones. Thus

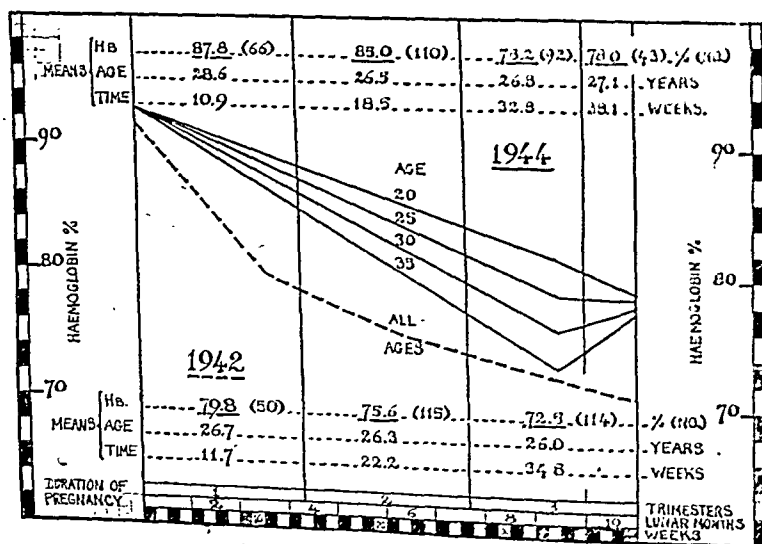


FIG. 1.

THE MEAN HAEMOGLOBIN LEVELS OF WOMEN DURING PREGNANCY.

The graph showing the mean changes in level for 1942 (interrupted line) is interpolated between the means for each trimester of pregnancy and that for non-pregnant women. The graphs for 1944 (entire lines) are, up to the 34th week calculated from the formula

$$\text{Hb.} = [92.75 - 0.064 (\text{age} \times \text{length of pregnancy in lunar months})] \text{ per cent}$$
 and those for the 34th to 40th weeks from the data on women seen in the last month.

seen once, 58 twice, 29 three times and 5 four times.

The numbers seen in each trimester are shown in Table I. In Table III and Fig. 1 are shown the mean haemoglobin levels for each trimester and for the last month.

when the 92 values found between the 27th and 36th weeks (mean time - 32.8 weeks), were considered, it was found that the regression coefficient of haemoglobin level on age was -0.5 (standard error 0.17, $t = 2.93$, $p = 0.01$). The difference due to

age was, therefore, significant and for each additional year of age the mean haemoglobin percentage was 0.5 less.

Similar regression coefficients could be obtained for the first and second trimesters, but as the differences here were smaller they were not significant when taken alone.

This method of grouping the results according to the trimester introduced artificial divisions and was inaccurate in that variations in the time of testing, within the trimester, were not allowed for.

was in calendar months. There was no figure available to show the mean haemoglobin level of non-pregnant women in Edinburgh in 1944, but the mean centre of the series of pregnant women was 83.3 per cent Hb. at a mean age of 27.1 years and mean time of 5.4 lunar months, and by substituting these figures in the above formula, it became:

Mean Hb. = $[92.75 - 0.064 (\text{Age} \times \text{length of pregnancy})]$ per cent.

Indirectly it thus appeared that the mean

TABLE III.
The Mean Haemoglobin Levels of Pregnant Women, 1942 and 1944.

Trimester	No. of estimations	Mean, time seen, weeks	Mean age, years	Mean Hb. per cent	Standard deviation
1942					
1st.	(50)	11.7	26.7	79.8	8.7
2nd.	(115)	22.2	26.3	75.6	8.7
3rd.	(114)	34.8	26.0	72.5	9.6
1944					
1st.	(66)	10.9	28.6	87.8	8.6
2nd.	(110)	18.5	26.5	85.0	6.8
3rd-36 weeks	(92)	32.8	26.8	78.2	10.0
37-40 weeks	(43)	38.1	27.1	78.0	9.4

* Variation for age and duration of pregnancy allowed for.

It was possible to consider all the results from the commencement of pregnancy up to the 36th week as one series in the following way. Since the haemoglobin level fell steadily during this time and since the fall was directly proportional to the age of the women, the mean haemoglobin level at any age and within this time could be expressed by the formula:

Mean Hb. + [Mean Hb. before pregnancy - C (Age \times length of pregnancy)] per cent.

The constant C is the regression coefficient relating the haemoglobin level to (Age \times length of pregnancy), and was found to be 0.064 (standard error = 0.007, $t = 9.09$), when the age was in years and the time in lunar months. It was 0.058 when the time

haemoglobin level of these women before pregnancy would have been 92.75 per cent. This figure compared well with those given in the Haemoglobin Survey for 1943, which were 92.5 per cent Hb. for 2,974 married women and 94.4 per cent Hb. for 4,813 unmarried women.

From this equation, the mean haemoglobin level of this series of women at any stage of pregnancy up to the 36th week and at any age could be calculated. The results so obtained for various age groups are given in Table IV and are shown graphically in Fig. 1. By means of the formula it is possible to compare the haemoglobin level of this group of women with that of any other, when the ages and durations of pregnancy are known.

It must be noted that the formula only gives mean haemoglobin levels. It can be applied to groups of women, but not with accuracy to individual cases. Within the series there were large individual variations. This is shown by the fact that the standard deviation of the mean of the whole

again parity was not found to have a significant effect on the haemoglobin level.

(b) 37th to 40th weeks.

The mean haemoglobin level of the 43 cases seen between the 36th and 40th weeks (mean time 38.1 weeks) was 78 per cent

TABLE IV.
The Expected Haemoglobin Levels in the Different Months of Pregnancy and at Different Ages.

Age, years	Hb. per cent								
	Calendar months								
	1	2	3	4	5	6	7	8	9
20	92	91	89	88	86	85	83	82	80
25	92	90	88	87	85	83	81	79	79
30	92	90	88	85	83	81	79	77	77
35	92	89	87	84	81	79	76	74	76

series of 268 estimations was +8 per cent Hb. Twenty-eight per cent of the women had haemoglobin levels which deviated from the expected by more than 8 per cent.

Examination of the effect of parity on the haemoglobin level affords an example of how the formula can be used. The mean figures for all values found in the first 36 weeks and also separately for those found between the 27th and 36th weeks, are shown in Table V, grouped according to parity. In the larger series the levels of the groups were very similar. Such small differences as were present were accounted for by variations in the length of pregnancy or age and the mean haemoglobin was in each case within 0.5 per cent Hb. of that found by calculation from the formula. In the group seen between the 27th and 36th weeks, the level of the primiparae was 4.5 per cent Hb. higher than that of the multiparae, but the true difference when age and duration of pregnancy were allowed for was only 1.3 per cent Hb. The standard error of the difference of the means was 1.9, which was greater than half 1.3; so the difference of 1.3 per cent Hb. was not significant. Thus

Hb. This value is the same as that found in the groups seen between the 27th and 36th weeks.

When the effect of age on the haemoglobin level was considered at this stage of pregnancy it was found to be less marked than earlier in the third trimester. The regression co-efficient of haemoglobin level on age was 0.25 (standard error = 0.25, $t = 0.95$, $p = 0.35$).

Thus the difference between yearly age groups in the last month was only 0.25 per cent Hb. as compared with 0.5 per cent Hb. earlier in the third trimester. It was not now statistically significant.

This result complements that found in the previous section when the effect of age on individual changes in haemoglobin level was considered. It was there shown that in the last weeks the rate of fall increased in the younger women, while the older women showed a rise. This suggested that any difference in haemoglobin level due to age which had become apparent in the first 36 weeks would tend to disappear in the last month. Here this has been shown to be so. It is probable that at term all ages would

have had the same mean haemoglobin level. The variations in the haemoglobin level with age are shown in the figure where the values found for the age groups 20, 25, 30 and 35 are shown separately.

3. *The Mean Haemoglobin Levels of Pregnant Women in 1942.*

The mean values found are shown in Table III and also in Fig. 1. The mean level in the 1st trimester was 79.8 per cent Hb. (50 cases), in the second 75.6 per cent Hb. (115 cases) and in the third 72.5 per cent Hb. (114 cases). In 1942 a series of 220 non-pregnant women was also investigated and their mean haemoglobin level was 91.6 per cent.

It is apparent from these figures that the haemoglobin level fell considerably throughout pregnancy, the most rapid fall occurring in the earlier months.

The mean values of the pregnant women were lower in 1942 than in 1944. In the first trimester the figures for 1942 and 1944 respectively were 79 per cent and 87 per cent Hb., and in the second trimester 75.6 per cent and 85 per cent Hb., and in the third trimester 72.5 per cent and 78.2 per cent Hb. The age of the subjects was again investigated but in this series it was not found to affect the haemoglobin level significantly. When the 114 cases seen in the third trimester were analysed a regression coefficient of haemoglobin level on age of 0.05 per cent Hb. for every year of age was obtained (standard error = 0.166, $t=0.32$, $p=0.8$). This was not significant and similar results were obtained in the first two trimesters.

Another difference from the 1944 series was that there was no tendency for the haemoglobin level to rise towards the end of pregnancy. The 24 cases seen in the last month had a mean of 68.6 per cent Hb., while the 90 cases seen earlier in the third trimester had a mean of 73 per cent Hb.

In order to investigate the effect of parity in this 1942 series, it was necessary to find the haemoglobin level to be expected at different times throughout pregnancy. As the rate of fall was not constant, the relation between haemoglobin level and time was not linear. But since the rate did not alter markedly between the 3rd and 10th months, when most of the observations were made, the use of a linear regression coefficient did not introduce large inaccuracies. The regression coefficient of haemoglobin level on the duration of pregnancy, or the fall in haemoglobin per lunar month, was found to be 1.44 (standard error = 0.25, $t=6.08$) and the mean expected haemoglobin level between the 3rd and 10th months was expressed by the formula:

$$\text{Mean Hb.} = [X - (1.44 \times \text{length of pregnancy})] \text{ per cent.}$$

When the mean values were substituted X was found to be 84.2. Since age did not in 1942 affect the haemoglobin level it was not necessary to consider it.

The figures for women of different parity are shown in Table V. There was a slight difference between the levels of primiparae and of the women in their second pregnancy, but this was not significant. When the women who had already had 2 pregnancies were compared with the others, however, it was found that there was an apparent difference of 3.3 per cent Hb. and a real difference, when the duration of pregnancy was considered, of 3.5 per cent Hb. (standard error = 1.55, $t=2.33$ and $p=0.02$). The difference was thus significant and it is apparent that in this series in 1942, women who had had 2 or more pregnancies previously, had a lower mean haemoglobin than had those in their first or second pregnancy.

Discussion.

It is clear that the results obtained in 1942 and 1944 were very different. They are

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compared in Tables III and V and Fig. 1. The most obvious difference is that the mean haemoglobin levels in each trimester of pregnancy were lower in 1942 than in 1944. From this it appears that in 1942 a larger proportion of the cases were anaemic. This point has already been discussed by us.^{1,2} In 1944 there were still probably some cases of anaemia and the inclusion of their haemoglobin values will have lowered the mean values. This is

moglobin level which was proportional to the age and greatest in the oldest women, and which continued till the last few weeks of pregnancy. In these last weeks the level of the older women rose, so that at term the level was the same for all ages, but was still below that of non-pregnant women. Primiparae and multiparae behaved in a similar way.

The fall in haemoglobin level during pregnancy has been found repeatedly. The

TABLE V.
The Effect of Parity on the Haemoglobin Levels of Pregnant Women, 1942 and 1944.

	No. of estimations	Mean Hb. per cent (1)	Mean age years	Mean time lunar months	Expected Hb. per cent (2)	Difference, (1)-(2)
1942						
Primiparae	(165)	75.3	24.5	6.4	75.0	0.3
Para I—	(75)	75.1	27.6	6.2	75.2	-0.1
Para I+	(39)	71.9	29.5	6.2	75.3	-3.4
	Apparent diff.	3.3			True diff.	3.5
1944						
7-36 weeks						
Primiparae	(166)	83.6	25.1	5.5	83.6	0
Para I	(55)	83.3	30.1	4.7	83.7	-0.4
Para I+	(47)	82.4	31.0	5.2	82.2	+0.2
27-36 weeks						
Primiparae	(64)	79.6	24.9	8.2	79.5	+0.1
Multiparae	(28)	75.1	31.1	8.2	76.3	-1.2
	Apparent diff.	4.5			True diff.	1.3

supported by the fact that higher mean values have at times been found, as by Boycott in a series from which subjects with colour indices below 0.91 were excluded, and by McCance *et al.*⁵ in a small series of well-to-do women. The incidence of true anaemia was, however, much lower in 1944 than in 1942 and the majority of the cases, it is suggested, then showed changes in haemoglobin level which were normal in direction if not in extent.

In 1944 there was a steady fall in the haemoglobin level which was proportional to the age and greatest in the oldest women, and which continued till the last few weeks of pregnancy. In these last weeks the level of the older women rose, so that at term the level was the same for all ages, but was still below that of non-pregnant women. Primiparae and multiparae behaved in a similar way.

The fall in haemoglobin level during pregnancy has been found repeatedly. The most conclusive evidence is derived from observations made on the same women, throughout pregnancy, as was the case in the work of Kühnel,⁶ Galloway,⁷ Strauss and Castle,⁸ Dieckmann and Wegner,⁹ McGeorge,¹⁰ Boycott⁴ and Meyer-Wedell.¹¹ The extent of the fall in haemoglobin level in these series was in each case very similar to that found here, the lowest mean level being about 80 per cent Hb.

A rise in the haemoglobin level in the last month of pregnancy has also been fre-

quently noted.^{4, 6, 9, 10, 11, 12.} A higher level in the last month was also found in the 2 large series of single haemoglobin estimations during pregnancy reported by Fullerton,^{13a} and the Haemoglobin Survey.³

In only one series has age been reported as influencing the haemoglobin level.¹³ Since there are wide individual variations it is clear that the effect of age may be apparent only when large numbers are considered, nevertheless the fact that even in large series no effect has been found suggests that it may not be a constant feature.^{4, 8, 13b.}

A number of workers have investigated the effect of parity on the haemoglobin level and found no correlation.^{3, 4, 7, 8, 13.} Linder and Massey¹⁴ reported lower values than in multiparae, but it is not clear that this effect was not due to age.

The conclusions drawn from the 1942 series were as follows. In this year the fall in haemoglobin level was greater, and more rapid in the early months of pregnancy than it was in 1944. Women of all ages were equally affected by the fall, which continued throughout pregnancy to term. Multiparae exhibited lower haemoglobin levels than primiparae.

A review of the literature shows very few series with haemoglobin levels similar to those found here in 1942. Goodall and Gottlieb¹⁵ reported such a series and they also found that the multiparae had much lower values than the primiparae, but only when their pregnancies had occurred in close succession. Reid and Mackintosh¹⁶ observed women in 2 income groups. In the higher the incidence of anaemia was slight and the number of pregnancies had no effect until women with 5 children were considered. In the lower income group, however, there was a high incidence of anaemia and multiparae of all grades showed lower levels than the primiparae.

Two practical points emerge from these

results. The first is of importance when the haemoglobin levels of different series of pregnant women are being compared. It has been shown that the haemoglobin level falls during pregnancy and that the fall may vary with age and parity. It is therefore impossible to obtain an accurate comparison of different series unless all these factors are taken into account.

The second point is of interest to the obstetrician. The extent of the normal fall in haemoglobin level during pregnancy is still not definitely established, but it is suggested that the levels found in 1944 (shown in Table IV) approach the normal and may be used as standards until supplanted. Since there were large individual deviations from these mean values, at first sight it appears that it is not possible from these figures to predict the haemoglobin level of any individual during pregnancy with any useful degree of precision. But the deviations, when account was taken of length of pregnancy and age, were, in fact, no greater than those found in any series of normal people. Thus the standard deviation of the 1944 series of pregnant women, allowing for length of pregnancy and age, was 8 per cent Hb., while that of the haemoglobin of 1,115 single men, very few of whom were anaemic, was 9.02 per cent Hb. (Haemoglobin Survey, 1945). It therefore appears that the haemoglobin level can be predicted as accurately in pregnant women as in other groups, provided the above factors are considered.

SUMMARY.

1. The haemoglobin levels of pregnant women in one antenatal clinic were investigated in 1942 and 1944. In 1944 the level of a number of women was followed throughout pregnancy.

2. In 1942 the haemoglobin level fell sharply in the first months and then more slowly to term. Women with 2 or more

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previous pregnancies exhibited lower levels than the others. Age did not affect the level.

3. In 1944 there was a fall in the haemoglobin level during pregnancy but this was not so great as in 1942. The fall was proportional to the age of the women and was steady until the last few weeks, the level of the older women then rose, so that at term there was no difference between different age groups. Parity did not affect the haemoglobin level.

4. The changes in the haemoglobin level are discussed and the importance emphasized, of considering the effect of the duration of pregnancy, the age and the parity on the level.

5. The haemoglobin levels to be expected in the different months of pregnancy and at different ages are tabulated.

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Stillbirth and Neonatal Death : A Clinico-pathological Study

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FOETAL and neonatal deaths together number something in the region of 43,000 per year in England and Wales, and although the total infantile death-rate has shown a reduction in recent years, the immediate neonatal period is still the least satisfactory. Several papers have recently been published on various aspects of this problem, which in view of the risk of a decline in population due to a reduction in the average size of the family has important social, as well as medical, implications. The surveys in this country have tended to be on general lines, while in America the autopsy findings in several large series have been more fully analysed relative to the obstetric data.

This paper is based on 327 autopsies performed on foetuses and infants delivered in the maternity department of Crumpsall Hospital, Manchester, and on 46 autopsies on infants in the neonatal group at the Booth Hall Hospital for Sick Children, Manchester. The detailed obstetric history was known in all the Crumpsall cases and could be correlated with the postmortem findings. In no other group is the close collaboration of pathologist and clinician so essential: without the clinician the autopsy findings cannot be interpreted; without a pathological examination opinion on the cause of death is often little better than guess-work.

The series does not represent an even per-

centage of the total number of stillbirths and neonatal deaths occurring in Crumpsall Hospital during the 7 years under review, since, in the early years, the cases for autopsy were selected on account of some unusual clinical features and where the cause of death appeared obvious an autopsy was not done. Unfortunately, during the early period prematurity was too readily accepted as a cause of death without further examination, but during the 2 years an attempt has been made to have autopsies whenever possible. Therefore the figures and percentages given should be regarded as applying to this series only and not strictly representative of the total number of stillbirths and neonatal deaths occurring in the hospital. The figures for 1945, when 80 per cent of all the deaths were examined postmortem, are given for comparison with the full table.

It is necessary to define the terms used throughout this paper. The period covered is that between the viability of the foetus (taken as 28 weeks gestation) and the end of the 4th week of life. This arbitrary end-point is a convenient one, giving an approximate limit to the period in which birth factors may be expected to play their chief part. We have accepted the general opinion with regard to prematurity, that weight is the more reliable guide and any foetus or child weighing $5\frac{1}{2}$ pounds or less has been recorded as premature, although we realize

that sometimes immature would be a much more suitable term.

The arrangement of the tables follows closely that given by Potter and Adair¹ in their book "Fetal and Neonatal Death" in order to make possible a comparison with American figures. It is difficult to know how to state the cause of death in this age group since it is possible to classify the pathological findings in so many different ways. Asphyxia, for instance, may be due to intracranial haemorrhage, cord

death, and therefore prematurity is separately discussed as a factor which runs horizontally through the vertical groups into which we have divided our cases.

Table I gives a summary of the cases on which this paper is based.

Intracranial Haemorrhage (Table II).

There is no need in this paper to discuss the mode of causation of intracranial haemorrhage during labour, as this is well understood, but it is worth mentioning that

TABLE I.
Causes of Death as Demonstrated at Autopsy.
373 cases: 223 livebirths: 150 stillbirths

Cause of death	Crumpsall				Booth Hall		Total	Percentage
	Stillbirth Neonatal death							
	Pre-mature	Full time	Pre-mature	Full time	Pre-mature	Full time		
Haemorrhage	4	24	14	19	—	3	64	17.2
Asphyxia	25	49	12	15	—	—	101	27.1
Atelectasis	—	—	12	6	5	—	23	6.16
Infections	—	—	26	26	3	17	72	19.3
Miscellaneous (including erythroblastosis)	6	1	4	15	—	8	34	9.1
Congenital abnormalities	9	2	7	11	—	10	39	10.45
Placental insufficiency	2	2	—	—	—	—	4	1.07
No pathological change	12	14	6	4	—	—	36	9.65
Total	58	92	81	96	8	38	373	100.0

complications or prolonged labour, or may result from a severe congenital heart lesion, et cetera. The method adopted by Potter and Adair, of giving the chief pathological lesion responsible for death, is followed in this paper and although open to criticism it does enable any further factors to be considered under the main headings.

It will be noted that prematurity is not given as a primary cause of death. We agree with MacGregor² that prematurity should be considered either as a predisposing or a contributory factor in many deaths but seldom a satisfactory sole cause of

if the head is not examined carefully and systematically at autopsy the evidence of intracranial injury may be destroyed. The head should be opened by cutting with scissors along the vertex on either side of the falx and removing the vault of the skull in two pieces: each cerebral hemisphere should be removed separately, noting any haemorrhage either on the surface of the brain or in its substance. This method gives a clear exposure of the whole of the falx and tentoria. We have not always found it easy to assess the amount of intracranial haemorrhage necessary to cause

death, as it is often impossible to tell how much damage has been caused by pressure on the respiratory centre. Our opinion is that such haemorrhage should be fairly gross before one can be reasonably certain that it is the only lethal factor since we have evidence of improved obstetric practice resulting directly from Holland's work and in particular from the use of episiotomy in breech delivery, which he advocated so strongly.

It is of interest to note that in the remain-

TABLE II.
Sixty-four Deaths due to Intracranial Haemorrhage

Type of labour	Stillbirths		Neonatal deaths	
	Premature	Full time	Premature	Full time
Normal cephalic	2	8	9	9
Prolonged or difficult labour	-	3	-	3
Induction of labour	-	3	-	1
Quick second stage	-	-	-	1
Forceps'	-	7	1	6
Breech	2	2	3	-
Version and extraction	-	1	1	2
Caesarean section	-	-	-	-
Total	4	24	14	22

occasionally seen signs of non-fatal intracranial haemorrhage in infants dying later from quite different conditions.

Where we have found intracerebral haemorrhage, not uncommonly into the ventricles, without any evidence of damage to the falx or tentoria, we have considered the cause of such haemorrhage to be asphyxia and have classified it as such.

The 64 cases in this series where intracranial haemorrhage was shown to be the cause of death formed 16.1 per cent of the total. Eardley Holland³ in his series found that of the fresh foetuses examined 48 per cent of the deaths were due to intracranial haemorrhage, the majority of these being the result of breech delivery, forceps delivery, or delivery through a contracted pelvis: a few only resulted from normal cephalic delivery. Our cases show a very different distribution—14 resulting from forceps delivery, 7 from breech delivery, and 4 from internal version and breech extraction. This may be taken as definite

ing 39 cases (60 per cent) spontaneous vertex delivery had occurred. Of these there had been prolonged labour in 6, while in 1 there was a very rapid delivery. Labour had been induced by a combined drug induction (puitritin in doses of 2.5 units but no quinine) and artificial rupture of the membranes in 4 of the cases. In the remaining 28 cases nothing abnormal was observed about the labour or delivery. A reduced foetal mortality from this cause in normal deliveries as it has been in breech deliveries, might be attained by a wider use of episiotomy. Holland pointed out the greater liability of the head of the premature foetus to tentorial tear, and in this series 18 were premature. Dr. Mary Crosse⁴ has advocated episiotomy in the delivery of premature infants.

Asphyxia (Table III).

This is a condition in which the foetus dies from lack of oxygen and, since it is completely dependent on the oxygen it receives

TABLE III.
Analysis of 101 Deaths due to Asphyxia.

	Normal cephalic			Forceps			Breech			Version and extraction			Caesarean section		
	S.B.	N.D.	P.	S.B.	N.D.	P.	S.B.	N.D.	P.	S.B.	N.D.	P.	S.B.	N.D.	P.
	F.T.	F.T.	F.T.	F.T.	F.T.	F.T.	F.T.	F.T.	F.T.	F.T.	F.T.	F.T.	F.T.	F.T.	F.T.
Accidental antepartum haemorrhage ...	7	5	-	-	-	-	1	-	-	-	-	-	-	-	-
Placenta praevia ...	1	1	-	-	-	-	-	-	-	-	-	-	1	3	2
Prolonged labour ...	-	1	-	2	-	-	-	-	-	-	-	-	-	-	1
Cord complications ...	3	12	-	1	-	-	-	-	-	-	-	-	1	-	-
Toxaemia in mother ...	6	5	3	-	-	-	-	-	-	-	-	-	-	-	-
Medical complications ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
No maternal complications ...	6	14	5	7	-	2	1	-	1	-	4	-	1	-	-

S.B. = Stillbirth.
N.D. = Neonatal death.
P. = Premature.
F.T. = Full time.

through the cord from the placenta, various complications may arise to interfere with this supply either before or during labour, resulting in stillbirth, or the damage to the infant may be so severe that it survives birth for only a short time. As would be expected, therefore, this group of 101 cases (36 per cent of the whole) is the largest in the series. Seventy-four of these were stillbirths and 27 livebirths.

The subject has been reviewed recently by Parsons,⁵ and MacGregor² and from our experience we agree with their general observations. In this paper we will limit ourselves to analysing the various obstetric factors which contributed to death. The autopsy findings were characteristic but very variable in extent; dusky skin, general engorgement of the veins, petechial haemorrhages, especially beneath the visceral pleura and in the thymus, haemorrhages of varying size beneath the epicardium on the surface of the heart, and occasionally more massive haemorrhage into the brain or adrenals. We have placed in a separate group as examples of atelectasis, cases where the lung has failed to expand but where none of the signs of asphyxia were found at autopsy, although we agree with MacGregor that most of these cases are probably asphyxial in origin.

In Table III the deaths in this group have been separated according to the type of labour and other obstetric findings. In 24 there was accidental antepartum haemorrhage or placenta praevia, and asphyxia was due to interference with the blood supply at the placental end. Definite toxæmia in the mother was present in 14 and in many of these there was a sufficient degree of placental insufficiency due to infarction to cause asphyxia in the child; prolonged labour leading to foetal distress was a factor in another 7 cases.

More controversial perhaps is the group of 17 where the asphyxia has been attributed

to cord complications. It is generally accepted that a prolapsed cord will result in death of the foetus unless conditions are favourable for immediate delivery. The question of the effect of a cord found tightly wound round the neck is more open to discussion. In recent correspondence in the *British Medical Journal*⁶ the view has been expressed that a cord twisted round the neck of the foetus was seldom if ever the cause of death, since the placental insertion moved down during labour and therefore the cord was not unduly stretched. This is not our view. We have had in this series macerated and fresh foetuses showing evidence of asphyxia in which there seems no doubt that the cord wound tightly round the neck was the cause of foetal death. This has occurred in spite of the usual precautions of feeling for the cord after delivery of the head and slipping the cord over the head or dividing it between forceps.

In a large proportion of cases (41 out of 101) no cause for the asphyxial signs was found, in spite of a careful review of the obstetric details. Probably a certain number of these could have been prevented by a more careful auscultation of the foetal heart during the second stage of labour.

The part which morphia, hyocine and the barbiturates may play in the production of asphyxia is well recognized. However, careful examination of all the case records in this group showed that none of these things had been used.

Atelectasis (Table IV).

In this group we have included 23 infants, most of them dying within a few hours of birth but some surviving in a precarious condition for several days. The important finding in this group, which we have called atelectasis, was that the lungs, or at least large portions of them, had failed to expand. Very commonly the lungs as a whole seemed solid and sank in water but there

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were generally a few patches of emphysema, sometimes bullous, on the free margins. It is admitted that the same factors may operate here as those which result in asphyxia and the difference may be only one of degree, but it has been thought worth while to differentiate between the two types of case. We have excluded from the atelectasis group any with the classical signs of asphyxia or haemorrhage or any in

TABLE IV.
Atelectasis 23 Cases.

	Natural cephalic	Forceps	Breech	Version and extraction	Caesarean section
Premature	16	1	-	-	-
Full time	5	1	-	-	-

which we have demonstrated evidence of lung infection microscopically. Prematurity was undoubtedly the important factor in 17 of these 23 cases. MacGregor² said that atelectasis should never be given as a cause of death and that the so-called cases were really examples of asphyxia through depression of the respiratory centre during birth and inhalation of liquor amnii, meconium or vernix. It is quite likely that depression of the respiratory centre may be the cause, at least it cannot be denied, but in the group we are discussing there were no signs of asphyxia and no indication of insufflation.

A systematic examination of the lungs of these infants makes one realize afresh the unreliability of the "floating test" as evidence of livebirth, in spite of the fact that it is still largely relied upon for medico-legal purposes to prove that the child has or has not breathed. We have had cases in this series where the lungs and all portions of them have sunk completely in water and where the child has survived birth for some 2 or 3 hours and been heard to cry; we have

also had examples of lungs floating well when the clinical evidence was that the child was stillborn, and therefore respiration must have taken place during birth. It is essential in doubtful cases to examine the lungs microscopically for evidence both of aeration and insufflation and even this evidence may not be conclusive.

Infections (Table V).

Infections present a different problem from the conditions so far discussed, as here the maternal condition and obstetric history, apart from prematurity, are not usually determining factors. The infections are important, not only because of the high percentage of neonatal deaths which they cause, but because during the last few years it has been felt that a reduction of mortality from infection should be well within reach.

From the Registrar General's figures, two facts emerge: (1) Although there has been a very welcome reduction of some 20 per cent in infantile mortality during the last 10 years, the worst group is still that of infants between 1 and 4 weeks old. (2) The total infantile mortality in 1943 for England and Wales, at 49 per 1,000 livebirths compares unfavourably with the figure of 31 for New Zealand and 30 for New York City. The conditions most responsible for the difference are enteritis and diarrhoea, bronchitis and pneumonia: in short they are all infections.

In the present series infection is considered to have been responsible for 72 (19.3 per cent) of all the deaths or 31.7 per cent of those in the neonatal group. Other writers give the following incidence of infections as the cause of death: Adair *et al.*⁷ 8.7 per cent in 483 neonatal deaths; Bundesen *et al.*⁸ 10.3 per cent of 1,043 infants less than 14 days old; Gibberd⁹ 12 per cent, although it is not clearly stated whether these are autopsy figures; MacGregor² 40 per cent; McNeil¹⁰ 27 per cent

and Henderson¹¹ 22 per cent. These figures are sufficient to show that if a child survives the hazards of birth the risk of infection is its greatest danger, and this danger is enhanced if the child is premature.

Table V shows that more than half the deaths were due to infections of the respiratory tract, and more generally staphylococcal. Many of these occurred in the 1st week and the majority within the first 2

TABLE V.
Analysis of Infections.

Type of infection	Premature	Full time
Lung infections	24	18
Gastro-enteritis	1	5
Meningitis	-	4
Infections of urinary tract ...	-	3
Peritonitis (cause not found)	-	3
Paralytic ileus	-	2
Umbilical sepsis	-	2
Staphylococcal skin infections	-	3
Osteomyelitis	-	1
Staphylococcal endocarditis	1	-
Thrush	1	-
Streptococcal nasopharyngitis	1	-
Congenital syphilis	1	1
Encephalitis	-	1
Total	29	43

weeks of life. To assess the true incidence of lung infections it is essential to take swabs for culture at the time of the autopsy and to examine sections of the lungs microscopically, as naked-eye appearances alone may be fallacious. The lungs sometimes show multiple small abscesses; often, especially in prematures, the lung is dark red in colour and completely solid. Benians¹² has shown how soon the skin and nasal passages of an infant acquire staphylococci and in weakly babies with the liability to inhale particles of food, and lungs which are often imperfectly expanded, the conditions are very favourable for staphylococcal infection. Evidence of aspiration was present in a

few but we consider most to have been due to airborne infection. There seems little doubt that the risk of infection is greater in hospital than it is in the home, and with the present preference for institutional midwifery the problem is one of increasing importance. Penicillin might give favourable results and is now being tried. The diagnosis is admittedly so difficult and the progress of the disease so rapid that penicillin will have to be given very early if it is to be effective. We have come to the conclusion that it is justifiable to give penicillin as soon as an infant, especially if premature, begins to go off its food, which is the first sign of danger. In Crumpsall Hospital the babies, except the prematures, are nursed in cots at the side of the mother's bed, and not packed closely together in nurseries. At present there is no special premature nursery and the premature infants are nursed in the ward nurseries, where the accommodation is insufficient and unsuitable in many respects. A new premature unit has been planned, based on the principles outlined by Dr. Mary Crosse of Birmingham.⁴

A note on the other infections may now be made. Gastro-enteritis has occurred only once in the Crumpsall series, and there have been but 5 cases at Booth Hall Children's Hospital in the age group under consideration. This may be due to the fact that the babies in Crumpsall Hospital have been almost entirely breast fed and the prematures have been fed on expressed breast milk, but it is realized that a small epidemic of enteritis, such as recently occurred in other hospitals in the Manchester area, might easily upset these figures.

There were 4 cases of meningitis, 2 pneumococcal and 2 due to *Bacterium coli*. MacGregor² has noted that in young infants *Bacterium coli* has unusual invasive powers not generally seen at a later age.

Congenital syphilis, histologically confirmed, accounted for only 2 deaths and a

similar low incidence has been noted by most recent writers on neonatal infection. It contrasts with Holland's series, where 16 per cent of his stillbirths were thought to be due to congenital syphilis.

Two interesting infections were an osteomyelitis of the femur in an infant of 3 days and a staphylococcal endocarditis in one of 11 days.

Purulent peritonitis, for which a primary cause was not found and in which the umbilicus did not show signs of infection, accounted for 3 deaths and in another 2 cases there was well-developed paralytic ileus, presumably infective, but without any obvious primary focus.

Neonatal infection was reviewed by Parsons in his Charles West Lecture in 1943, and the findings in our series merely serve to emphasize the truth of his observations.

The earlier cases were diagnosed as icterus gravis on clinical and histological grounds, but since the discovery of the Rh factor it has been possible to establish a more certain diagnosis, and in 9 of the later cases the opinion has been confirmed serologically. Death took place most often in the first few days of life and as one would expect the condition generally occurred in a second or later child. The relative frequency of erythroblastosis (accounting for approximately 6 per cent of all the deaths investigated) and the fact that prompt recognition and immediate treatment are essential, has led us to adopt the following routine:

(1) Every woman attending the antenatal clinic has her red cells tested for the Rh factor, and if Rh negative her serum is examined during the last few weeks of pregnancy for the presence of Rh antibodies.

TABLE VI.
Miscellaneous Causes of Death. 34 Cases.

Cause of death	Stillbirth		Neonatal death		
	Pre-mature	Full time	Pre-mature	Full time	
				Crumpsall	Booth Hall
Erythroblastosis foetalis (icterus gravis) ...	3	-	1	10	6
Hydrops foetalis ...	1	-	2	-	-
Haemorrhagic disease of newborn ...	-	-	-	1	1
Thrombosis of renal veins ...	-	-	-	1	-
Jaundice (cause not ascertained) ...	-	-	1	-	-
Polyserositis ...	-	1	-	-	-
Reticulo-sarcoma of thorax ...	-	-	-	-	1
Toxaemic changes in liver ...	2	-	-	2	-

Miscellaneous Causes of Death (Table VI).

In Table I there is a miscellaneous column which includes 34 cases fully analysed in Table VI. It will be seen that 20 of these deaths, 3 stillborn and 17 neonatal, fall into one group of erythroblastosis foetalis (icterus gravis type) and there are in addition 3 cases of hydrops foetalis which is generally regarded as a more advanced manifestation of the same condition.

(2) Any Rh negative mothers, found to have anti-Rh agglutinins in their serum, should be admitted to hospital for the last month of pregnancy, and if there is a rise in the agglutinin-titre labour should be induced.

(3) Special watch is kept on the infants born to these Rh negative women and if the child shows any sign of jaundice its blood is immediately tested for the Rh

factor and the haemoglobin estimated. Transfusion, with Rh negative blood, is given if there is any significant fall in the haemoglobin level and transfusion is repeated if necessary using the haemoglobin level as a guide.

(4) All blood taken from donors is tested for the Rh factor and in this way a panel of Rh negative donors, available for both mother and child, is gradually being formed.

By these methods it has already been possible to save several infants suffering from erythroblastosis, in some cases where an earlier child of the same parents has died from this condition. It is impossible at present to say whether all these children will be normal in every way as there is a risk of kernicterus and possibly of mental deficiency, but it does seem that this is a group for which much may be done in the future.

There were only 2 cases of haemorrhagic

18 days (an incidental finding and not a cause of death) and a reticulosarcoma of the thorax in a child of 2 days.

It has generally been accepted that toxæmia in the mother may influence the child chiefly through placental infarction and placental insufficiency leading to asphyxia, but 4 of our cases suggest that occasionally the toxins circulating in the mother's blood may pass through the placenta and cause damage to the liver of the child. Two were stillborn and 2 were neonatal deaths and the mothers had definite toxæmia. In 1, the liver changes were similar to those found in women dying of toxæmia of pregnancy; 2 showed extensive generalized fatty change and 1 severe cloudy swelling with nuclear degenerative changes.

Congenital Abnormalities.

These are set out in Table VII. It is not necessary here to deal with these in any

TABLE VII.
Distribution of 39 Congenital Abnormalities.

Type of abnormality	Stillbirths		Neonatal deaths	
	Premature	Full time	Premature	Full time
Congenital heart	—	1	1	11
Diaphragmatic hernia	1	—	3	—
Anencephaly	4	1	—	—
Hydrocephalus and spina bifida	1	—	—	1
Hydrocephalus	1	—	—	—
Atresia of oesophagus	—	—	—	1
Multiple deformities	2	—	1	3
Hydronephrosis	—	—	1	1
Maldevelopment of kidney	—	—	1	—
Atresia of intestinal tract	—	—	—	3
Cleft palate (with bronchopneumonia)	—	—	—	1
Totals	9	2	7	21

disease, both intestinal haemorrhages, probably due to vitamin K deficiency.

Two tumours were found in the series, a neuroblastoma of the adrenal in a child of

detail as they represent what is probably the irreducible residue of foetal and neonatal deaths for which nothing can be done. It has recently been suggested that some

congenital abnormalities might be associated with rubella infection of the mother during the first 3 months of pregnancy. We have made careful enquiries among the mothers of children showing these abnormalities: a history of rubella has not been obtained in the 25 we have been able to trace.

The malformations account for 10.7 per cent of all the deaths. In the literature it is striking that the percentage of congenital abnormalities recorded is extremely variable and when such figures as 30 per cent are given it strongly suggests that the series is unduly selective and that an excessive proportion of cases likely to be of special interest have been included. To some extent, therefore, the percentage of these abnormalities may be an indication of the extent to which any given series is truly representative, and judged by this criterion our figures are not unduly biased. Reference is made to this point in the section dealing with the figures for 1945.

Autopsies in which the Cause of Death was not Determined.

Lastly we come to the group set out in Table VIII where the cause of death was

not found at autopsy. In a few of these it was known that the mother suffered from toxæmia, syphilis or diabetes which did not cause any pathological lesions in the foetus. It is quite possible that some deaths in this group might be due to placental insufficiency, since in the early stages of this investigation examination of the placenta was not made. The rest in this group are evidence of our ignorance of the pathology of this period of life. Help was not obtained from the obstetric history since the majority were associated with normal cephalic deliveries.

Consideration of the Figures for the Year 1945.

It is instructive to consider separately the autopsy results for the year 1945 and to correlate them with the total births for that year:

Stillbirths		Livebirths		Total births	
Pre-mature	Full time	Pre-mature	Full time	Pre-mature	Full time
59	40	201	2064	260	2104
99		2265		2364	

This gives a total stillbirth incidence of 99 in 2,364 (41.8 per 1,000) and a prema-

TABLE VIII.
Thirty-six Autopsies where Cause of Death was not Determined.

Type of delivery	Normal cephalic				Forceps				Breech				Version and extraction				Caesarean Section			
	S.B.		N.D.		S.B.		N.D.		S.B.		N.D.		S.B.		N.D.		S.B.		N.D.	
Maternal condition	P.	F.T.	P.	F.T.	P.	F.T.	P.	F.T.	P.	F.T.	P.	F.T.	P.	F.T.	P.	F.T.	P.	F.T.	P.	F.T.
Toxaemia	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syphilis	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diabetes	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-
No maternal complications	7	7	3	3	-	-	-	-	1	2	1	-	-	-	-	-	1	-	-	-

S.B. = Stillbirths.
N.D. = Neonatal death.
P. = Premature.
F.T. = Full time.

ture stillbirth incidence of 59 in 260 (227 per 1,000).

For the same period there were 79 neonatal deaths, 54 premature and 25 full time.

The neonatal death-incidence was therefore 79 in 2,265 (34.9 per 1,000 livebirths), and the premature neonatal death-incidence 54 in 201 (269 per 1,000 livebirths).

These figures show the large part played by prematurity in the stillbirth and neonatal mortality-rates. Of the combined stillbirths and neonatal deaths 59 and 54 respectively were premature, i.e. 63.59 per cent.

During this year an attempt was made to increase the numbers of postmortems performed; consequently 63 of the 99 stillbirths and 67 of the 79 neonatal deaths were so examined and the findings are summarized in Table IX.

unfortunate that an autopsy was not performed in 100 per cent of the cases because it is only in this way that a true idea can be obtained of the relative incidence of the various factors involved. The records of the 36 stillbirths and 12 neonatal deaths which had not received full postmortem examination were therefore summarized and the result given in Table X.

Of these it is seen that 13 are recorded as gross congenital abnormalities, 12 being anencephalic and 1 hydrocephalic with spina bifida. It seems justifiable to add these 13 to the list of postmortems performed thereby obtaining for the year a more accurate picture of the relative incidence of the various causes of foetal death. When this is done it is found that congenital malformation accounts for approximately 20

TABLE IX.
Cause of Death as Demonstrated at Autopsy (Year 1945 only).

Cause of death	Stillbirth		Neonatal death		Total	Percentage
	Pre-mature	Full time	Pre-mature	Full time		
Haemorrhage	1	4	9	4	18	13.85
Asphyxia	18	16	9	4	47	36.2
Atelectasis	—	—	2	—	2	1.54
Infections	—	—	17	9	26	20.9
Miscellaneous (including erythroblastosis)	1	—	2	1	4	3.08
Congenital abnormality	5	3	2	5	15	11.5
Placental insufficiency	2	2	—	—	4	3.08
No pathological change	6	5	3	—	14	10.77
Total	33	30	44	23	130	100.0

The percentage incidence of the pathological findings at autopsy is seen to be very similar to that for the whole series as given in Table I. One very obvious difference is that of the 130 cases in Table IX; 77, i.e. 59.2 per cent, were premature, whereas for the whole series only 31.6 per cent were premature. This is explained by the fact that in the early years very few premature bodies were examined. It is

per cent of the total figure, which is still very much lower than that given in many publications.

DISCUSSION.

A comparison between Table I and Table IX shows that for the whole series of autopsies pathological lesions were not found in 36 per cent, while for 1945 this figure was 11 per cent. We feel that this is

chiefly due to our greater experience in interpreting the postmortem changes.

Finding a cause of death is more satisfactory than having to record a negative postmortem result, but it is the search for the determining factors in some of these deaths which is obviously most important. In this we, in common with most other writers, have been only partially successful and, especially in the asphyxia and atelec-

TABLE X.

Forty-eight Cases During Year 1945 not Examined Postmortem.

	Stillbirths	
	Pre-mature	Full time
Gross congenital abnormalities ...	11	2
Cord complications	3	3
Toxaemia	2	1
Toxaemia and diabetes	—	1
Accidental antepartum haemorrhage	2	1
Placenta praevia	1	—
Destructive operation	—	1
Cause not known	4	2
Maternal syphilis	2	—
	Neonatal deaths	
	Pre-mature	Full time
Internal version and breech extraction	—	1
Lived under 24 hours	7	—
Lived over 24 hours	4	—

tasis groups, the mode of delivery and the maternal condition by no means always give a satisfactory explanation. The tables themselves and the remarks we have made under the various headings will emphasize this. What is undoubtedly significant, running parallel through most of the groups is the influence of prematurity, most pronounced where death was due to asphyxia, atelectasis or infection. Baird¹³ has recently discussed some of the factors involved in prematurity and he notes how

much more frequent this condition is in the lower income groups owing to the poor health and nutrition of the mother. Most of our cases were in these lower income groups and if Baird's analysis of the position is accepted, the remedy lies in measures directed to improving the general standard of living of these mothers together with special measures for nursing premature infants. Prematurity is so important a factor in many of these deaths that we feel that premature labour should only be induced for very definite reasons and should whenever possible be delayed until the gestation has reached 34 to 36 weeks.

It may be profitable to consider again the groups we have adopted in this paper to see if any particular measures are available for reducing the mortality rate.

(a) Intracranial haemorrhage. It is in a sense disappointing that many deaths due to this cause followed normal cephalic deliveries in which no other known factor was involved. An episiotomy would save some of the premature foetuses and it is probable that the same operation, followed if necessary by a low forceps delivery which could all be done with local anaesthesia, might prevent some of the others.

(b) Asphyxia and atelectasis. Prematurity is the largest single factor and has already been discussed. No less than 43 per cent of these 2 groups were premature. Many of the cases in these groups are due to antepartum haemorrhage and are largely unavoidable. While this is true also of cord complications, i.e. prolapse and cord round the neck, it is probable that many which fall into this category together with some of the unexplained ones could be prevented by careful auscultation of the foetal heart in the second stage. Steps could then be taken to hasten the delivery if this was indicated and if the conditions were favourable.

(c) Infections. Here there is very definite

room for improvement. Again prematurity is an important factor and much more may yet be done to protect the premature child from infection during the critical first few weeks of life. Parsons has epitomized much that has been written and said on this subject and his advice means the provision of adequate accommodation and facilities for the child as well as the mother in all maternity departments and more careful nursing than has been available in the past. The reduction of infection of the respiratory tract, which accounts for a high proportion of the deaths investigated here should be possible and the establishment of nurseries for the premature staffed by specially trained nurses are an immediate necessity.

(d) Erythroblastosis. The discovery of the Rh factor has opened a new field for the diagnosis and treatment of erythroblastosis, a condition which accounted for 6 per cent of the deaths investigated. We have indicated that the routine examination of the blood of all pregnant women for the Rh factor, careful watch on the infants of Rh negative mothers and prompt treatment with Rh negative blood if the child shows signs of haemolytic disease, are the measures necessary. We know from personal experience that many of these children can be saved; we do not yet know what proportion of these children will show evidence of mental deficiency resulting from kernicterus.

(e) Congenital abnormalities. It should be possible to reach a decision on the question of the relationship between rubella and other infectious diseases in the mother and the incidence of congenital defects, especially cardiac, in the child. In this very small number we have not had any supporting evidence. We understand that the Ministry of Health has undertaken to collect figures and preventive measures must await more definite evidence than has yet been produced.

SUMMARY.

1. This paper is based on an analysis of autopsy findings in 373 cases of stillbirth and neonatal death, correlated with observations of the mode of delivery and any relevant maternal conditions.

2. A separate analysis of figures for 1 year is given for comparison with the full series.

3. The importance of prematurity in relation to many of the deaths in this age group is again stressed.

4. Infection, especially in premature infants, is one of the most important factors in neonatal death.

5. The value of episiotomy is noted and its extended use for the prevention of stillbirth and neonatal death suggested.

6. Erythroblastosis foetalis is discussed and a routine suggested for the diagnosis and treatment of this condition.

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Primary Carcinoma of the Fallopian Tube

(A Report of Four Cases)

BY

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PRIMARY carcinoma of the Fallopian tube is a rare condition and, although the volume of literature on the subject has increased considerably in recent years, most of it has come from Continental and American clinics.

There has been little written on the condition in English journals for many years, and in view of the recent cases seen by members of the staff of this hospital, it was considered worth while:

- (1) To add a further 4 cases to the literature;
- (2) To review the literature as fully as wartime deficiencies would allow, and
- (3) To analyse some of the more recently reported cases in an effort to present a comprehensive picture of the condition.

HISTORICAL.

There seems little doubt that the first authentic case of the disease was reported by Orthmann¹ in 1886. With this statement both Baron² and Martzloff³ agree.

Henderson,⁴ however, gives priority to Orthmann as writing in 1888, as do Lofgren and Dockerty.⁵ In the paper to which these authorities are referring,⁶ Orthmann mentions the cases of Senger and Gottschalk described in 1886, both however diagnosed as tubal sarcomata with meta-

stases in the pouch of Douglas. In the absence of adequate pathological evidence both these cases are of doubtful authenticity. Orthmann presents 13 cases collected from the literature; but dismisses them all as examples of secondary tubal involvement. The only case he accepts as authentic is his own, described in 1886.

Several authors^{7, 8} writing before Orthmann had suggested that carcinoma of the Fallopian tube might arise as a separate disease entity, and Rokitansky⁹ gave a good pathological description in 1861. The claims made for Raynaud, as the reporter of the first case in 1847 by several writers including Robinson,¹⁰ Jeanneney and Soubiran¹¹ and more recently Addis,¹² appear to be without foundation.

In 1895 Sanger and Barth¹³ collected 17 cases previously reported in the literature, but dismissed several of them as cases of papillomata of the Fallopian tube.

The first case reported in England was that of Doran in 1888.¹⁴

INCIDENCE.

The number of cases reported is difficult to estimate because, as Martzloff³ showed, some cases have been reported twice and others overlooked.

By 1903 Peham¹⁵ had collected 63 cases. This figure rose to 84 in 1906 (Orthmann),¹⁶ 100 in 1910 (Doran),¹⁴ and 244 by 1929 (Wharton and Krock).¹⁷ Nurnberger col-

lected 301 cases occurring between 1886 and 1931. Kahn and Norris,¹⁸ however, had only quoted 270 cases by 1934. Robinson in 1935 accepted Nurnberger's figures, collected 48 further cases from the literature, added one of his own, and so brought the total to about 350. Martzloff by 1938 had added 32 cases from the literature and one of his own, bringing the total to 383.

By the end of 1944 the total of reported cases was about 450.

Since 1944 the writer has been able to collect only the case reported by Ayre,¹⁹ and the 16 from the Mayo Clinic, some of which had previously been reported by Holland, and 3 reported by Addis. Including therefore the 4 cases here presented, the probable total is nearer 465 and the 376 quoted by McGoldrick.²⁰

The rate of occurrence quoted by many authorities in a disease as rare as this can be of little value. Figures are given varying as widely as 5 cases in 35,000 gynaecological admissions at the University of Pennsylvania,¹⁷ to 1 per cent in 995 gynaecological admissions at the Frauenklinik Berlin (Schmit).

Of the 4 cases quoted in this paper, Cases 1 and 4 are the only ones known to have occurred in this hospital during the past 25 years, the total number of patients admitted to the gynaecological department being 9881. Martzloff gives the rate of occurrence as 0.5 per cent of operative procedures on the Fallopian tubes.

Perhaps the truest estimate of frequency is that of Cameron: "The condition is so rare that many gynaecologists never see it."

CASE REPORTS.

CASE 1.

A married woman, aged 48 years, with 2 children, had enjoyed excellent health until 1 year before admission, when she noticed a swelling of the abdomen unaccompanied by pain. Six months before admission her abdomen enlarged rapidly

and she was admitted on March 16th, 1925, under the care of Mr. Victor Bonney.

On examination a mass was found to fill the pelvis, the nature of which it was impossible to determine. On March 19th the abdomen was opened; both Fallopian tubes were enormously dilated and bound to the uterus by light adhesions. The remaining pelvic contents appeared normal. Primary carcinoma of the Fallopian tubes was suspected, and the uterus and both tubes and ovaries were removed. The patient made an uneventful recovery and was discharged home. She was re-admitted on March 26th, 1926, having noticed a hard lump in the abdomen and considerable swelling since November 1925.

Seventeen pints of bloodstained fluid were removed by tapping, after which a lower abdominal mass and enlarged spleen were both readily palpable. The patient was discharged on June 24th, 1926, and died at home in August of the same year, 16 months after the original operation. A post-mortem examination was not performed.

Pathological report. The specimen removed consisted of the uterus and both Fallopian tubes and ovaries. The ovaries and uterus were normal both macro- and microscopically. Both Fallopian tubes were dilated to about 1 inch in diameter—the left to form a large cyst at its fimbriated end. Both tubes were adherent to the superior and posterior surfaces of the uterus. The inner surfaces of the Fallopian tubes were covered by numerous thick papillary masses, which coalesced in places to form solid tumours. Microscopically there was invasion of all coats by tubular carcinoma with solid areas of polygonal cells (Fig. 1).

CASE 2.

A married woman, aged 38 years, had suffered from heavy and irregular periods for 1 year. Ten months before admission she noticed pain in the back at the onset of her periods. She was admitted to hospital on September 24th, 1945, under the care of Mr. W. R. Winterton, with a provisional diagnosis of uterine fibroids. On admission, it was noticed that she had marked lower abdominal tenderness, and a large polyp was seen protruding through the cervix. Laparotomy on September 25th, 1945, revealed a distended left Fallopian tube adherent to the omentum and surrounding structures; otherwise the pelvis was normal. The left

Fallopian tube and ovary were removed, and some small fibroids by myomectomy. The abdomen was then closed, and the cervical polyp was twisted off *per vaginam*. The patient made an uneventful recovery and was discharged on October 15th, 1945. She subsequently attended the radiotherapy department of this hospital, and received a total tumour dose of 3528 R and deep X-radiation to the pelvis over 5 fields in a total of 28 treatments.

When last seen on April 17th, 1946, she was in excellent health and the pelvis appeared normal.

Pathological Report. The specimen consisted of a distended Fallopian tube sealed at the fimbriated end, with a normal ovary attached. On incision, the Fallopian tube showed mild fibrosis and one small papillomatous growth in its outer third. Microscopically the tube showed marked chronic inflammatory changes with an area of invasion by mainly undifferentiated polygonal cell carcinoma, but some attempted tubule formation.

CASE 3.

A married woman, aged 60, first sought advice because of continuous vaginal haemorrhage for 18 months. For the last year she had suffered from severe backache, worse in the early morning. She had had 7 children and 2 miscarriages. On examination abnormal physical signs were not detected, except for a symptomless enlargement of the thyroid gland, present, she said, for at least 30 years. She was admitted to hospital on January 11th, 1946, under the care of Mr. Carnac Rivett. At laparotomy, a tumour the size of a walnut was detected in the outer third of the left Fallopian tube. It was sealed at its fimbriated end, and there were filmy pelvic adhesions present. A diagnosis of probable carcinoma of the Fallopian tube was made, and total hysterectomy and left salpingo-oophorectomy performed. Local or distant metastases were not detected. She made an uneventful recovery, and was discharged one month after admission. Deep X-radiation was not given. The patient's goitre rapidly became toxic which necessitated a partial thyroidectomy 2 months later. Pathologically this was an adenoma of the thyroid. When last seen she was in excellent health and there was no evidence of recurrence.

Pathological Report. The specimen consisted of the uterus and left tube and ovary. The uterus and left ovary were normal macro- and microscopically. The left Fallopian tube showed a solid tumour the size of a walnut in its outer third. The rest of the tube was normal in appearance (Fig. 2). It was sealed at its fimbriated end. Microscopically there was invasion of the coats of the Fallopian tube by papillary carcinoma. The greater part of the growth appeared regular and well differentiated, but mitoses were frequent. (Fig. 3.)

CASE 4.

A married woman, aged 49, nulliparous, complained of continuous pain in the left iliac fossa for 6 months, accompanied by acute exacerbations. A white creamy discharge had been present for a year. Six months before admission her periods had ceased, except for two recent small losses of blood. She had noticed pain occasionally shooting down the inner aspect of the left thigh. She was admitted under the care of Mr. Carnac Rivett, on the 12th February, 1946, and on examination a large abdominal tumour arising from the pelvis and reaching to the level of the umbilicus was discovered. Fluctuation was elicited bimanually and a diagnosis of ovarian cyst was made. At laparotomy an enormously dilated left Fallopian tube was discovered, adherent to the uterus, pelvic colon, and side wall of the pelvis. In attempting to free it, it ruptured, and a few ml. of opalescent fluid escaped into the general peritoneal cavity. The left tube was finally freed and removed, together with the right ovary and slightly dilated right Fallopian tube, and the uterus by subtotal hysterectomy. The patient made an uninterrupted recovery and was discharged 25 days later. When last seen she was in good health and there was no evidence of recurrence. Postoperative radiotherapy was not given.

Pathological Report. The specimen consisted of the body of the uterus, a mildly dilated right tube and macroscopically normal ovary, and an enormously dilated left tube and small ovary of normal appearance.

The right tube showed a hydrosalpinx with fibrotic changes in the wall only. The left tube was greatly enlarged, and contained a large papillary growth at its fimbrial end, a central dilated portion

free of growth and a second papillary growth at the uterine end of the tube (Fig 5.) Both growths were wholly confined within the tube; both ovaries and the uterus were microscopically normal. Microscopically there was irregular papillary overgrowth of lining epithelium with invasion of deeper tissues by polygonal celled carcinoma. The cells of the growth were small and undifferentiated in character (Fig. 4).

Aetiology. An extensive search through the literature has thrown little light on this. There is an abundance of theory with little factual support. There is general agreement that it is a disease with its heaviest incidence at the menopause and the years immediately succeeding it. Cases have, however, been reported as young as 18 (Johnson and Miller²¹) and as old as 80 (Fullerton²²). Wechsler²³ states that 66 per cent of cases occur in the age group 45-55. Of the 33 cases recently analysed, 22 fell into the age group 45-60.

The part played by previous inflammation as an aetiological factor finds support in the writings of Doran, Sanger and Barth and Orthmann, and more recently Ewing.²⁴ Ruge and Vest (quoted by Barrows²⁵), and more recently Fullerton, Hobbs²⁶ and McGoldrick deny any such association.

Vest²⁷ considered that inflammation was the result rather than the cause of carcinoma of the Fallopian tube. The modern view is perhaps best summarized by Frankl²⁸ writing in 1914: "If inflammation were to be a precursor of carcinoma of the tube, the incidence of malignancy should be much higher, for salpingitis is overwhelmingly common." Of the 33 cases analysed, there were very few in whom there was good evidence of previous tubal inflammation.

Von Franque (quoted by Baron), L'Esperance²⁹, and more recently Ewing, and Lofgren and Dockerty point to cases where tuberculosis has also been present in the tube. Fullerton, however, suggests that some of these cases have been confused

histologically, and stresses the occasional microscopical similarity between the two conditions. Douglass and Faulkner³⁰ go so far as to state that quite a few cases diagnosed as carcinoma are actually tuberculous. They suggest that tubal tuberculosis might predispose to papillomata, a supposedly pre-cancerous condition. The influence of parity and fertility on the condition is impossible to assess. Whitehouse and Doran state that it is more common in the parous than non-parous, a view not upheld by most recent authors.

Wharton³¹ has recently suggested that the great infrequency of tubal carcinoma as compared with carcinoma of the cervix and uterine body may be associated with the different activities undertaken by the relative mucosal linings. He draws attention to the fact that the endometrium and the cervical mucous membrane are constantly altering throughout menstrual life, whereas the lining of the Fallopian tube remains relatively quiescent. The tubal mucous membrane is also much less subject to trauma. In view of this statement it is interesting to remember that many of these tumours arise in the postmenopausal years when the whole genital tract is relatively quiescent.

Pathology.

Carcinoma of the tube usually arises in the middle or outer portions of the tube. According to McGoldrick 70 per cent occur at the fimbriated end and 30 per cent at the isthmus. In the latter situation he considers that the prognosis is worse. Case 4 in this paper shows one tumour mass present at the isthmus and one at the fimbriated end. There is also a small nodule occupying the middle third. The spread in this case was almost certainly via the lumen of the Fallopian tube.

The fimbriated end is often sealed quite early in the disease; this is thought to im-

prove the prognosis in some cases by preventing dissemination throughout the general peritoneal cavity. In the 4 cases here presented the fimbriated end was sealed.

The condition is bilateral in about one-third of the total cases. The growth varies in size from a small malignant plaque (Case 2) to a large fungating mass that may or may not be still limited to the tube (Case 4).

In the past it was usual to describe 3 types of growth, the papillary, the adenomatous and the alveolar; but now the view is widely held that these types are merely stages in a continuous pathological process, the adenomatous and alveolar types arising by compression of the papillae in the papillary type (Phaneuf³² and Ewing).

It should be noted that the term adenocarcinoma is an unfortunate one, there being no true glands in the Fallopian tube.

The malignant process bursts through the muscular wall of the tube only as a late event, although widespread lymphatic metastases may occur from quite well-circumscribed growths (Corbet³³). Of the 33 cases studied in the literature, at the time of operation there were only 3 cases with evidence of intraperitoneal metastases, and in 2 of these the inguinal glands were involved. This is important in view of the long period that usually elapses between the first symptoms and diagnosis.

Spread may occasionally occur through the abdominal ostium to give rise to a carcinomatosis peritonei and ascites. Other modes of spread are via the round ligaments to the inguinal nodes via the lymphatics to the iliac and aortic glands, and via the blood stream to the liver and lungs. Secondaries have also been reported in the cervical and supraclavicular glands.

The ovary is only rarely involved in a

growth that is primarily tubal, though spread to the uterus via the lumen of the tube may occur.

Secondaries may occur in the cervix and vagina, perhaps the most distressing case being that reported by Henderson where a secondary deposit appeared in the cervix 2 years after a successful subtotal hysterectomy and bilateral salpingo-oöphorectomy. It is interesting to note that of 33 recently reported cases, only 3 had to be abandoned surgically because of the spread of the growth.

Physical Signs.

The physical signs in this condition are seldom characteristic. It is possible that a combination of them may raise the suspicion of carcinoma of the tube. Very few correct preoperative diagnoses have been made.

The triad of lower abdominal pain (often of a colicky nature), watery or bloodstained vaginal discharge sometimes varying in amount with the colic, and a lateral pelvic mass, should arouse suspicion of tubal malignancy.

Of the 33 patients reviewed, 11 complained of abdominal pain, 9 had vaginal discharge, 8 had "post-menopausal bleeding", and 8 had some upset of menstrual function. A mass was present in 21 out of 33 cases, but in only 2 was there also discharge and abdominal pain.

The onset of the disease is often very insidious, the first sign may be a change in menstrual habit before the menopause or heavy bleeding if the condition occurs after the menopause. The duration of symptoms varies from less than 1 month to more than 2 years.

The presence of associated pathological lesions in the pelvis add to the difficulty of diagnosis. Doran found ascites present in 2 cases in his series of 127, fibroids in 5 per cent, and ovarian cysts in 10 per cent. Out

of 33 cases, 3 cases of fibroids were found, and 1 ovarian cyst, in all cases responsible for obscuring the diagnosis.

Hobbs lays most stress on a sero-sanguineous discharge as a diagnostic aid, especially if it is associated with tubal colic (*hydrops tubae profluens*). He states that this is only present in 1 of 3 conditions: uterine carcinoma, tubal torsion or carcinoma of the tube. A discharge obviously of uterine origin that persists after curettage should suggest tubal malignancy.²⁰ These points would be of more value if most cases presented with vaginal discharge. Unfortunately this is not so. If there is an adnexal swelling of doubtful nature in the pouch of Douglas, posterior colpotomy and the possible recovery of malignant cells, might settle an otherwise doubtful diagnosis.² According to Hoenig and Warner³⁴ the conditions that are most often confused with carcinoma of the tube are menopausal bleeding, ovarian cysts, salpingitis, endometriosis, ectopic gestation, carcinoma of the uterus and ovary and granulosa-cell tumours of the ovary. A careful clinical examination and history may obviate many of these diagnoses, and a negative curettage with persistent bleeding is suggestive. A presumptive diagnosis of extrauterine pregnancy and granulosa-cell tumour of the ovary can often be made on the appearances of the curettings. Hormonal assay may also be of value in differentiating granulosa-cell tumours. In spite of this, however, Wharton and Krock doubt whether a correct diagnosis can be made when the disease arises in the childbearing period of life.

The presence of ascites is uncommon with carcinoma of the tube, in contradistinction to carcinoma of the ovary. In only 2 of 33 collected cases was ascites present. Hysterosalpingography may be of value in diagnosis. The risk of forcing cancerous material into the general peritoneal cavity

is apparently minimal. A positive diagnosis of carcinoma of the tube cannot be made on a hysterosalpingography, but it may be useful in ruling out various intra-uterine pathological conditions that show as filling defects.

A correct pre-operative diagnosis was made in only 2 of the 33 collected cases. Looking at these cases in retrospect it seems unlikely that it was possible to reach a correct diagnosis. The 4 cases described here could hardly have been diagnosed correctly in view of the obscure and confusing clinical picture.

TREATMENT AND PROGNOSIS.

Total hysterectomy and bilateral salpingo-oöphorectomy is agreed by most authorities to be the correct preliminary method of treatment. There is, however, no universal agreement on the place of radiotherapy in after treatment. Many authors including Baron, Phaneuf and more recently McGoldrick and Lofgren and Dockerty, are in favour of postoperative, deep X-radiation. Wharton and Krock question its value, and Martzloff states that there is no evidence that deep X-ray therapy is of any value. He points out that the number of cases treated is small, and that the period between treatment and assessment of its value is often too brief for any conclusions to be drawn. He collected 22 cases treated by X-rays from the literature; of these, 10 were dead and 8 alive, of whom 5 had been alive less than 1 year, and in 7 the outcome was not stated. There are, on the other hand, cases that have lived for many years without X-ray therapy. The outlook, whatever the treatment, is bad. Many of the survival-figures are of no value as the cases have not been adequately followed up and the time of survival is often not stated. The overall 5-year cure-rate is probably not more than 4 per cent.

This bad prognosis is due to a number of factors of which late diagnosis and inadequate surgical removal are probably the most important. The extreme malignancy of the condition is obviously a contributory factor. Until clinicians bear the condition in mind in every case of obscure adnexal disease, few additions are likely to be made to the 8 correctly diagnosed cases in the literature. Wharton and Krock state that in only a third of the reported cases was the extent of the surgery adequate. This is sometimes due to a misdiagnosis being made at laparotomy, a state of affairs that may be remedied by the practice of opening in the theatre all Fallopian tubes removed, and the submission of doubtful areas of frozen section.

Hobbs appears to be the only authority who advises the conservation of the uterus at operation, so that it may be used for the postoperative insertion of radium. All the 33 cases collected from the literature were treated by surgery in the first instance. Only 3 cases were abandoned as beyond surgical aid. In several an inadequate operation was done, and in 2 cases the abdomen was reopened and a more radical procedure carried out. In others, including Case 2 of this personal series, it was considered that the disease was in an early limited stage and further surgery was unwarranted. It is impossible to say whether further surgery added anything to the survival of these few cases. Ten of the 33 cases had deep X-radiotherapy, 1 both before and after operation, and 1 in combination with intrauterine radium.

Of the 10 cases treated by radiotherapy, 5 were alive at periods varying from 6 months to 4 years, and 5 had died, all within 2 years. Of the 23 cases treated by surgery alone, 6 were alive for periods varying from 1 month to 15 years, 7 had died all in under 4 years, and in 10 the end result was not stated. From figures such as these it is im-

possible to draw any conclusions except to suggest that both forms of treatment will probably give poor results until the diagnosis can be made more rapidly and with greater certainty.

Summary.

Four cases of carcinoma of the Fallopian tube are presented. Two cases (1 and 4) are from the records of Middlesex Hospital, and are the only cases known to have occurred there during the past 25 years. The other 2 (Cases 2 and 3) have been under the care of members of the staff and have been followed up at this hospital.

The recent literature has been scrutinized and 33 reported cases analysed.

Several points emerge:

1. The difficulty of diagnosis of the disease.
2. The bad prognosis in almost all cases.
3. The inadequate surgery to which many of the cases were subjected.
4. The doubtful value of deep X-ray therapy.

In none of the 4 reported cases was a correct clinical diagnosis made, and only twice in the collected group of 33.

The difficulty of preoperative diagnosis does not seem capable of resolution until the condition is more frequently borne in mind by clinicians, and doubtful cases in which symptoms persist after palliative treatment are subjected to laparotomy. Hysterosalpingography may occasionally be of value in differential diagnosis.

Radical surgery is undoubtedly the best line of treatment. Mistakes in diagnosis after the abdomen has been opened can easily be rectified by opening all Fallopian tubes removed and subjecting doubtful areas to frozen section. This procedure might also rule out the occasional case where the abdomen has to be opened for a second time to complete a radical clearance.

The value of deep X-rays is at best doubtful, as might be expected from the histological nature of the growth. Sufficient cases, however, have not been treated and followed up for a final judgment to be reached on their efficacy.

The suggestion is made that only by bearing the condition in mind in cases of unusual difficulty, early resort to laparotomy in unresponsive cases and employment of radical surgery in established cases, will the present high mortality be lowered.

My thanks are due to Mr. Victor Bonney, Mr. L. Carnac Rivett, and Mr. W. R. Winterton under whose care the patients were treated, for permission to publish this report; to the Bland-Sutton Institute of Pathology for permission to make use of the pathological material; to Dr. G. D. Hadley, T. R. Pilkington and Dr. Japha for their help with the foreign literature; and to Mr. W. H. Cheavin for his photographs.

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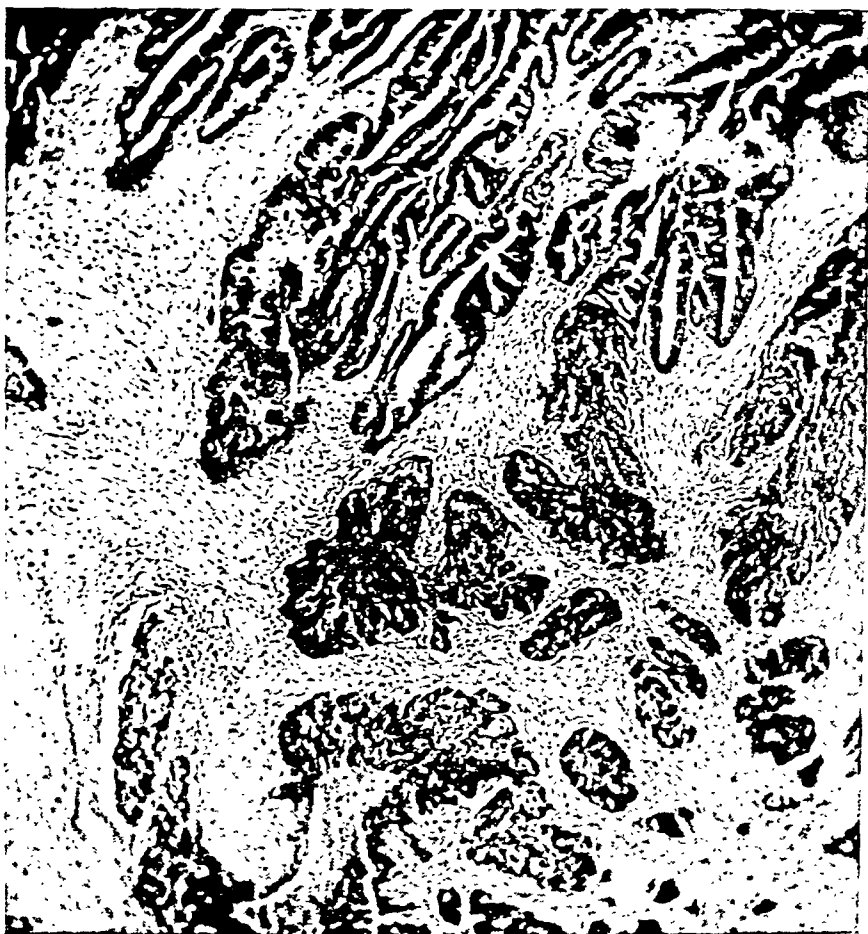


FIG. 1.

CASE 1. Showing at top right a somewhat hypertrophic mucous membrane.
Centre and bottom shows invasion by solid areas of malignant cells.

G. B.-L.

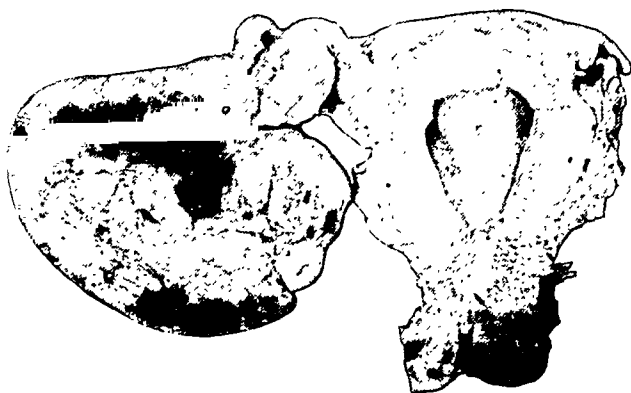


FIG. 2.

CASE 3. Showing normal uterus cut in coronal plane, and distal half of left Fallopian tube distended by soft, white encapsulated growth.

G. B.-L.



FIG. 3.

CASE 3. Showing invasion of the wall of the Fallopian tube by papillary carcinoma.

G. B.-L.



FIG. 4.

CASE 4. Showing hypertrophic malignant mucous membrane below left, and invasion of submucous layer by undifferentiated malignant cells above.

G. B.-L.



FIG. 5.

CASE 4. Normal atrophic uterus on right, with dilated left Fallopian tube filled with white necrotic growth.

G. B.-L.

Weather Changes and Eclampsia

BY

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PRE-ECLAMPSIA is a relatively common disease of late pregnancy, while eclampsia, which supervenes in a few of these cases, is uncommon. The incidence of eclampsia varies greatly in different parts of the world (Dieckmann¹). In Cape Town the disease occurs more frequently than in most other centres.

There is generally believed to be a seasonal incidence for eclampsia, and many obstetricians are of the opinion that a change in the weather is one factor which may be of importance. According to Dieckmann sudden meteorological changes may cause eclampsia in the susceptible individual. Arnell² recently stated that local atmospheric changes seem to furnish the only obvious common factor where eclampsia occurs in groups after long intervals without a case. Meteorograms studied at the time of onset of seizures of antepartum eclampsia showed that in 83 per cent (62 cases) the onset coincided with a rising barometric pressure, a decreasing environmental temperature and a high degree of humidity. In 6 instances tropical electrical storms were also present. Theobald³ has pointed out that the toxæmias of pregnancy are rare in Siam, and that the incidence of eclampsia in Ceylon is perhaps the highest in the world; yet the meteorological and living conditions are very similar in the two countries.

The weather has not been claimed to have any causal significance but may precipitate the patient with pre-eclampsia into convulsions or coma; this may result from con-

traction of the skin capillaries and a rise in blood-pressure while prevention of loss of heat and water would intensify the oedema. Abrupt changes in the physical milieu may accordingly require physiological adjustments beyond the capabilities of the abnormal individual.

A study of reports in the literature reveals much contradiction in the meteorological factors considered to predispose to eclampsia. This is well shown in Table I, modified from Dieckmann. In some reports only a few cases were studied, and statements have often been made based on impressions rather than on proper scientific evidence.

It was of interest to study records in Cape Town because the incidence of eclampsia is high, especially in the winter months—July to September—and because there is the impression that weather changes play some part. The incidence in Cape Town for the years 1925–34 has previously been published⁴ by Crichton⁴ and Goldberg.⁵ The monthly incidence of eclampsia in Cape Town for the years 1938–42 is shown in Table II; the table shows what appears to be a seasonal incidence, although the incidence of antepartum cases alone does not show any striking difference over the various months. Dieckmann reported different months of prevalence for different regions of the earth.

Since factors such as labour, operative procedures, et cetera, complicate intrapartum and postpartum eclampsia, only cases of antepartum eclampsia have been considered here. The records of 63 cases

TABLE I.

Author	Meteorological factors favouring eclampsia
Das	Temperature and humidity at a minimum
Sachweh	Warm and moist weather
Croom	Cold, rainy weather, with relative humidity high
v. Konrad	High humidity
Goldberg	High humidity
Merletti and Grappa	No relation to temperature. Barometric pressure, humidity and electric charge of the air important
Tottenham	Temperature low, humidity low (below 80 per cent)
Mitra and Ghosh	Maximum temperature important, humidity and rainfall unimportant
Bradford	Hot, wet climate
Fuestner and Sargent	Most cases correlated with the passing of a "cold" front
Arnell	Decreasing temperature, rising barometric pressure, and high humidity

TABLE II.
Peninsula Maternity Hospital.

	Total cases of eclampsia (White and coloured)											
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1938	1	2	2	3	3	1	2	4	6	0	1	1
1939	2	0	1	1	0	2	4	5	4	3	1	1
1940	1	1	2	3	2	1	3	3	1	2	3	0
1941	1	2	1	2	2	1	6	0	4	6	0	3
1942	3	2	1	1	1	2	3	1	1	2	2	1
Totals	8	7	7	10	8	7	18	13	16	13	7	6
	Cases of antepartum eclampsia											
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1938	1	2	1	1	2	1	1	0	1	0	0	0
1939	1	0	0	0	0	0	2	1	2	1	0	1
1940	1	0	0	2	2	1	1	3	0	2	3	0
1941	0	1	0	1	2	0	3	0	3	2	0	2
1942	0	2	0	0	0	1	0	1	0	0	0	0
Totals	3	5	1	4	6	3	7	5	6	5	3	3

of this type admitted to the Peninsula Maternity Hospital during 1938-43 were available for study, of which 45 were coloured patients (22 primiparae) and 18 were white (10 primiparae). An opportunity was taken while in Johannesburg (altitude 5,740 feet) to study the records of 20 cases of antepartum eclampsia (white) admitted to the Queen Victoria Hospital during the period 1937-43. In each of the cases the

time of onset of the first convulsion was known, and was studied in relation to the meteorological events (maximum and minimum temperatures, barometric pressure, humidity) for the day of onset and the preceding 4 or 5 days.

Weather charts prepared for 45 of the cases in Cape Town are presented in Fig. 1. In each chart the variations in daily maximum temperature are indicated at the top

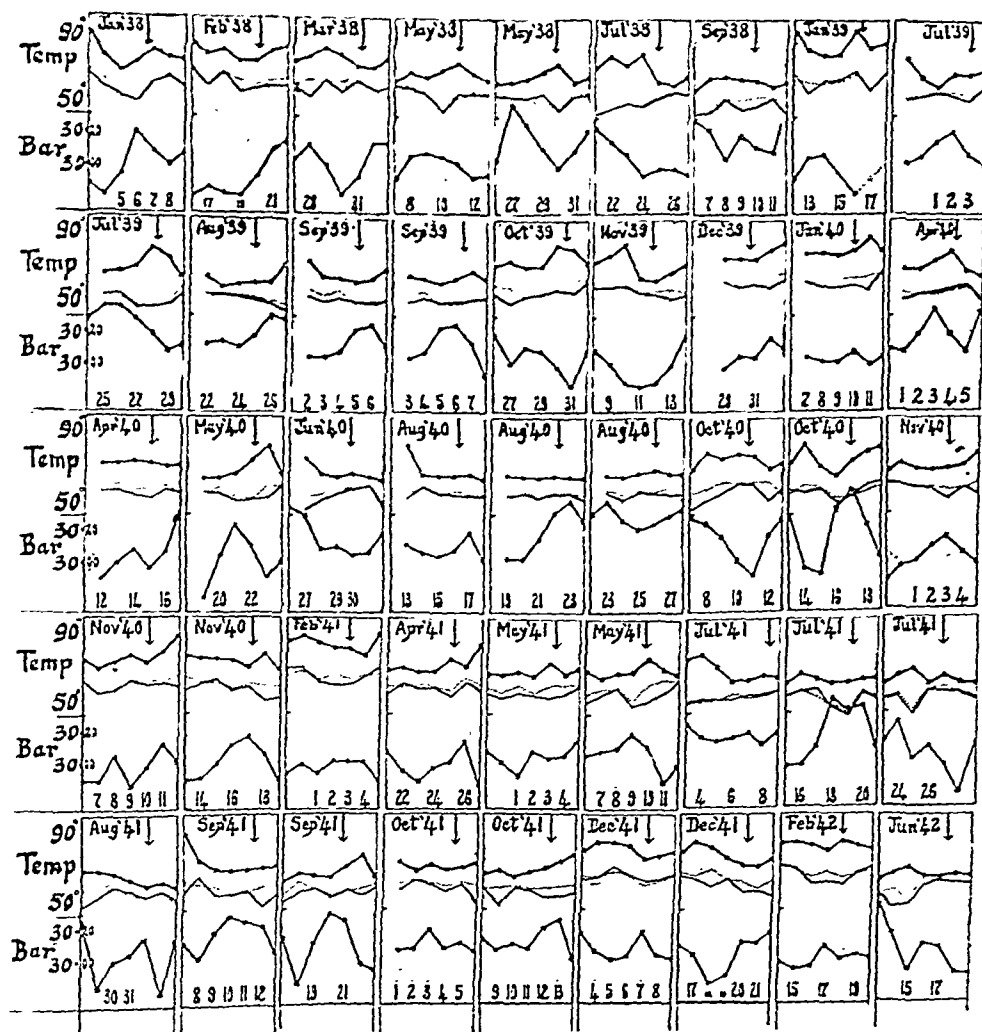


FIG. 1.

Meteorograms of 45 cases of Eclampsia.
Peninsula Maternity Hospital, Cape Town, 1938-43.

of the record, the minimum temperature just below this, the barometric pressure at the bottom of each record, and wet-bulb readings are indicated by a dotted line. Weather charts for the 20 cases in Johannesburg are shown in Fig. 2; in each

being given in the figures at the top or bottom of each meteorogram.

CONCLUSIONS.

Season in itself does not appear to be associated with eclampsia (Fuestner and

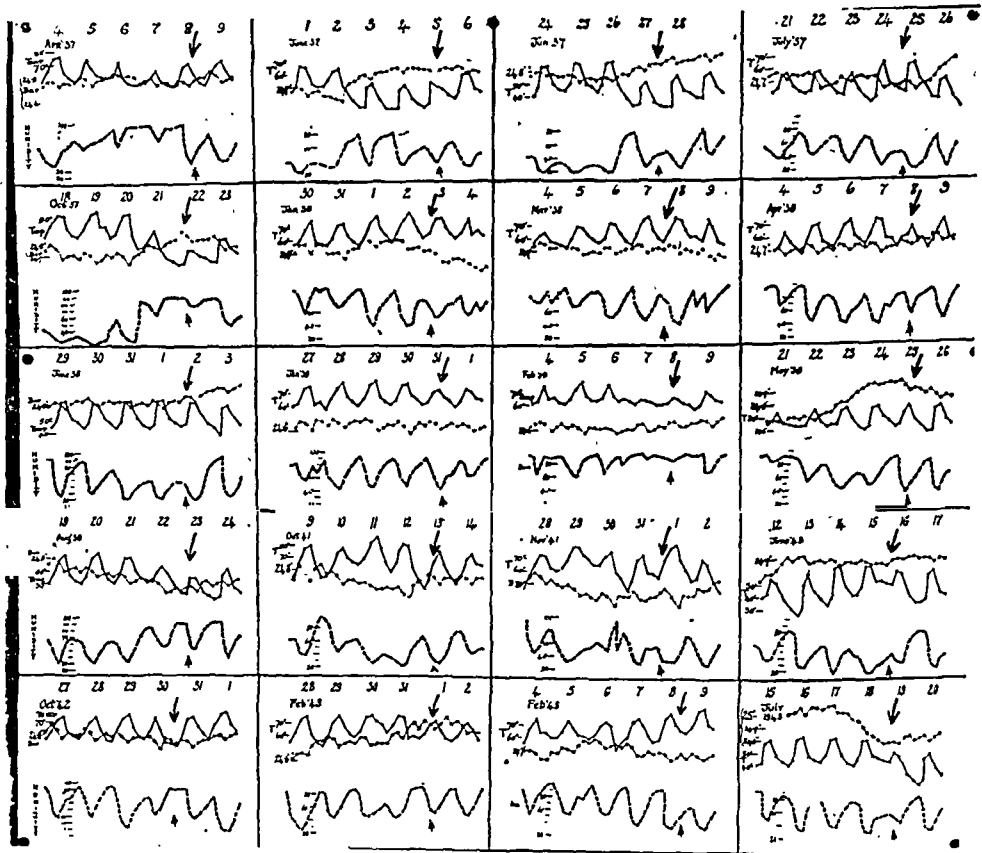


FIG. 2.

Meteorograms of 20 cases of Eclampsia.

Queen Victoria Hospital, Johannesburg, 1937-43.

case the maximum temperature readings are indicated by the heavy line, the barometric pressure by the dotted line, and the humidity by the interrupted line below. The vertical arrows show the time of onset of the first antepartum convulsion, the date

Sargent⁶); this is borne out by the figures for antepartum eclampsia in Table II. As far as weather changes are concerned correlation could not be found between the onset of antepartum eclampsia and the meteorological factors studied. Attempts

at statistical analysis of the values for these factors for the day of onset and the 4 or 5 days preceding the attack failed to yield significant results. A study of the charts, revealing the synchronous daily variations in the meteorological events, also failed to show common coincidental changes preceding the attack. The contradictory statements made by different authors further supports the view that some other factor must be sought to explain the onset and incidence of eclampsia, and the greater frequency of the disease in some centres than in others.

Permission to study the records was obtained from Professor E. C. Crichton (University of Cape Town) and Professor

J. Black (University of Witwatersrand) to whom thanks are due. Lieut.-Commander S. P. Jackson kindly furnished the meteorological data from which the charts were drawn and gave other valuable assistance.

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BOOK REVIEWS

"The Technical Minutiae of Extended Myomectomy and Ovarian Cystectomy." By VICTOR BONNEY. London: Cassell & Co., 1946. Price 30s. 282 pages.

MOST of us can recall reading at some time the preamble to myomectomy in Berkeley's and Bonney's "Textbook of Gynaecological Surgery," and the lasting delight that its grave and beautiful language and unaffected sensibility gave, so that as the years went by one came to quote the passage again and again as a sort of testament of our common aims. It is no exaggeration to say that at least a whole generation in this country and the Empire owes much of nicety of technique and confidence in strategy to Berkeley's and Bonney's great book, and the few who have been privileged to be taught by Mr. Bonney in person at the height of his powers cannot help but know that they have been fortunate indeed above their contemporaries.

The present book completes very perfectly the Textbook. Bonney is a Teacher. He has simplicity, invention and courage. Not the dry sticks of technical jargon rustle in his writings; his sentences have the true "clangour of bronze" that awakens response and memory. If his object has been to make conservative gynaecological surgery widely practised by making it "easy", it seems to me that he has succeeded. Every difficulty, small or great, that he has encountered since his gangling days is here demonstrated and overcome, although not even this author-artist can describe or depict the gentleness and deftness needed that operations of such extent and duration be safe or indeed possible. This is the one danger of this book. It is perhaps too much to ask that a book on the technical minutiae of such operative procedures as extended myomectomy include a short note on the wise use of plasma- or blood-transfusion, although, in the opinion of the reviewer, this would enhance its worth. For the rest, it is not possible to measure the praise and gratitude that is owing for this fine work or to do other than recommend its constant reading by every gynaecologist who claims, in Mr. Bonney's words, to be one of the "small group of a great host whose marching cry is 'something better'!"

This is an era when a declaration of high purpose is apt to be considered outmoded, immodest or insincere; when it seems to be taken for granted that the mastering impulse in medicine, too, must be wages and hours, a rate for a job. We have seen in our time the tradition of British craftsmanship, such as made our homes and our furniture the delight of the world, decline, and the mass-produced and jerry-built accepted by a public taste too debased for outcry. With schemes of state medicine requiring the mass-production of specialists, with the wastage of the past six years yet unremedied and with a decline of competition and criticism threatening, a debasing of our standards of surgery may truly be feared.

There is to be no time to stand and stare at the great craftsmen at their work and to learn beautiful surgery in leisurely apprenticeship. Therefore, Mr. Bonney's book is our peculiar gain at this moment, and for the future may compare with the drawing-book of Sheraton or the case-books of Smellie as an unmatched exposition of the technical minutiae of art and craft.

MEAVE KENNY.

"A Pocket Obstetrics." By ARTHUR C. H. BELL, M.B., B.S., F.R.C.S., F.R.C.O.G., Hon.M.M.S.A. London: J. & A. Churchill. 148 pages. Price 7s. 6d.

THIS little book is produced in the hope that it will be of help to general practitioners and midwives in their work, and to students for revision purposes. Clearly it is to the last class of reader that it will appeal most. In the busy days before the approaching final examinations a small book which may be carried in the pocket is appreciated by the student. It can be read at odd moments in train, tram or bus. But it must be clear, reasonably full and yet concise, dogmatic but with a discursive element. Its limitations must be obvious so that the reader is driven back to more comprehensive works in order to fill in the gaps. It must not attempt to supplant the textbook. It must come from an authoritative source.

These criteria are satisfied in this publication. The author's authority is unquestioned. The approach and practice professedly largely follow

that of *Queen Charlotte's Textbook of Obstetrics*, of which Mr. Bell is part author.

It is perhaps surprising to find the Prague seizure advocated in breech delivery, that eggs and onions should be avoided during sulphonamide administration, that Caesarean section should *never* be considered in the treatment of placenta praevia unless the patient is in good condition. That there are, of course, two sides to every question is an undergraduate's dilemma—particularly just before *viva voce*. Because his sense of proportion is not yet developed he magnifies this dilemma, for himself. Hence there is a need for sound, acceptable, orthodox teaching. Such the student will find in this little revision book. It can be thoroughly recommended provided it is used for the purpose for which it is written—revision.

The book is well and nicely printed on good paper and attractively bound.

ANTHONY W. PURDIE.

"A Practical Handbook of Midwifery and Gynaecology for Students and Practitioners." By W. F. T. HAULTAIN, O.B.E., M.C., B.A., M.B., Ch.B., F.R.C.P., F.R.C.S., F.R.C.O.G., and CLIFFORD KENNEDY, M.B., Ch.B., F.R.C.S., F.R.C.O.G. London: E. & S. Livingstone, 1946. 3rd. edition, 388 pages, 20s.

THIS book is written with the avowed object of being of use to final year students, younger practitioners and those practitioners returning from the Forces who desire a concise up-to-date presentation of midwifery and gynaecology. In other words it claims to be a short textbook.

The student does not always choose wisely the books he will read on any given subject. For this reason, at the beginning of a course of instruction, many teachers recommend a number of books from which the student may choose, according to his fancy, one or more from which he is bound to profit.

There are many qualities which go to make the good textbook. It must provide the student with sufficient factual knowledge to enable him to pass his professional examination on its subject matter. But it should do more than this. It should help him to understand the subject, it should stimulate him to think and reason (with himself at any

rate) about it. It should hint at fields of further study beyond the limits of the book itself to which, fired by the author's enthusiasm, he may turn when the examination goal is passed. Coming too, as it should, from the leaders of a learned profession it should be well written. The true synopsis is another matter altogether. It fulfils a different function and is used in conjunction with a textbook.

This book, in the reviewer's opinion is a cross between a textbook and a synopsis. It is written partly in tabular form and partly in staccato phrases or sentences. There must be few subjects within the student's range of obstetrics and gynaecology which are not mentioned. But it is very sketchy in many places. An example may make this clear. When the authors describe internal rotation in dealing with the mechanism of labour they refer to the work of Sellheim and of Moir. Their description of this is quoted in its entirety: "If a cylindrical body capable of bending on its long axis unequally in different directions is forced through a curved cylindrical passage, it will rotate in such a way as to adapt itself best to that canal and to allow bending to occur with the maximum ease. Internal rotation results in the long diameter of the skull being brought into the long antero-posterior diameter of the outlet." The enquiring student is not likely to be satisfied.

In the section devoted to the uses of X-rays in obstetrics and gynaecology pelvic mensuration and shape are dismissed thus: "When contraction or abnormal shape of the pelvis is suspected, X-ray examination may be most helpful. This applies to the false pelvis and to all levels of the true pelvis." There is no description of this use of X-rays in the chapter on contracted pelvis to justify the paucity of this description.

One could continue to elongate the sketchy and unsatisfactory exposition of many sections. The book will appeal most to the somewhat indifferent student with a good memory. He will be able to combine what he has acquired from good clinical teaching with what he has crammed from this book. He may elude the vigilance of his examiners and be satisfied. But to confine his obstetrical and gynaecological reading to this book will be decidedly to his impoverishment.

ANTHONY W. PURDIE.

ROYAL COLLEGE OF OBSTETRICIANS AND GYNAECOLOGISTS

A meeting of the Council was held in the College House on Saturday, July 27th, 1946, with the President, Mr. Eardley Holland, in the Chair.

Mr. William Gilliatt, C.V.O., M.D., M.S., F.R.C.S., F.R.C.O.G., was elected President to take office in September next.

The following officers were also elected:—

Vice-Presidents:

Robert Marshall Allan, M.C., M.D., F.R.A.C.S., Hon.F.A.C.S., F.R.C.O.G.

Sir William Fletcher Shaw, M.D., F.R.C.P., Hon.F.A.C.S., F.R.C.O.G.

The following candidates were elected to the Membership:

Hugh Rose Arthur.
Samuel James Barr.
Bryce Evans Blair.
Catherine Isobel Blyth.
Joyce Muriel Burt.
Harold, Burton.
Guy Beadon Walmsley Fisher.
Brojo Gopal Halder.
Robert Leighton Hartley.
Derek Jefferiss.
Iola Lloyd Trevor Jones.
Leslie Wallace Lauste.
Elizabeth McCallum.
Margaret Orford.
Hedley Charles Perry.
Dwifendra Lal Poddar.
Esther Mary Pollock.
J. Edmund Scott-Carmichael.
William Robert Sloan.
Robert Alexander Russell Taylor.
Eric Wilfred Lowther Thompson.
Thomas George Edward White.

INDEX TO CURRENT LITERATURE

In this Index and endeavour will be made, so far as conditions permit, to maintain an up-to-date record of all titles bearing on obstetrics and gynaecology and the infant. The classification aims at making immediately available for the reader the titles under the various subject headings. In the majority of instances the title is obtained from the original publication. Where this has been impossible, the title has been obtained from the abstracting journal shown in brackets. Reprints will be welcomed and should be sent to the Editor.

Any inquiries should be addressed to Miss D. F. Atkins, British Postgraduate Medical School, Ducane Road, London, W.12.

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ANATOMY

1. "Classification of the human pelvis, with a preliminary note on the evolution of the anthropoid or ultra-dolichopellic type of pelvis." O. S. Heyns. *Journ. Obstet. and Gynaecol. Brit. Emp.*, June 1946, LIII, 242-50.
2. "Accessory optic tracts in the human foetus." E. R. A. Cooper. *Brain*, 1946, LXIX, 45-9.

PHYSIOLOGY

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4. "Involution of tissues in fetal life." A. T. Hertig. *Journ. Gerontology*, January 1946, I, 96-117.
5. "The inactivation of pitocin and pitressin by human pregnancy blood." R. A. Woodbury, R. P. Ahlquist *et al.* *Journ. Pharm. Exper. Therap.*, April 1946, LXXXVI, 356-65.
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9. "A study of normal and abnormal menstrual function in the Auxiliary Territorial Service." C. M. Drillien. *Journ. Obstet. and Gynaecol. Brit. Emp.*, June 1946, LIII, 228-41.

PREGNANCY

NORMAL

Physiology

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Diagnosis

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13. "Les signes sympathiques de la gestation." (Subjective signs of pregnancy.) M. Rivière and Soullignac. *Gynéc. et Obstét.*, Paris, 1946, XLV, 96-109.

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Duration

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Antenatal care, examination

20. "Residential rest during the antenatal period." G. M. Allen-Williams and I. Sutherland. *Journ. Obstet. and Gynaecol. Brit. Emp.*, June 1946, LIII, 278-84.

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26. "Findings on examinations of newborn infants and infants during the neonatal period which appear to have a relationship to the diets of their mothers during pregnancy." H. C. Stuart. *Federation Proc.*, 1945, IV, 271-81. (*Nutr. Abstr. Rev.*, April 1946, XV, 748).

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Abortion, premature birth

36. "Further studies on the estrogen-progesterone treatment of habitual abortion." N. W. Vaux and A. E. Rakoff. *North Carolina Med. Journ.*, May 1946, VII, 202-8.

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Association with infections

53. "Die Sulfonamidzyanose der Schwangeren und ihre Behandlung mit Thionin." (Treatment of sulphonamide cyanosis in pregnancy with thionin.) R. Elert. *Wien. klin. Wschr.*, May 24th, 1946, LVIII, 279-82.

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Ectopic pregnancy

55. "Simultaneous extra- and intra-uterine pregnancy." M. Segal. *Brit. Med. Journ.*, June 8th, 1946, I, 878.

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57. "Les hémorragies intra-péritonéales d'origine génitale en dehors de la grossesse extra-utérine." (Intraperitoneal haemorrhage of genital origin in

ectopic pregnancy.) J. Cottalorda and F. Gavaudan. *Gynéc. et Obstét.* (Paris), 1946, XLV, 150-8.

58. "Full-time secondary abdominal pregnancy with delivery of living child." H. S. Waters. *Journ. Obstet. and Gynaecol. Brit. Emp.*, June 1946, LIII, 285-8.

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60. "Pregnancy in a uterus bicornis." D. W. Robinson. *Brit. Med. Journ.*, June 1st, 1946, I, 836.

61. "Pregnancy in a uterus bicornis" (letter). G. A. Armstrong. *Brit. Med. Journ.*, June 15th, 1946, I, 929.

62. "Extramembranous pregnancy." R. S. Siddall. *Amer. Journ. Obstet. and Gynecol.*, June 1946, LI, 897-900.

63. "Ovarian pregnancy." C. J. Stamm. *Amer. Journ. Obstet. and Gynecol.*, June 1946, LI, 908-9.

MISCELLANEOUS

64. "Emotional factors in the course of pregnancy." R. Squier and F. Dunbar. *Psychosomatic Med.*, May/June 1946, VIII, 161-75.

LABOUR

NORMAL

65. "Experiences with labor procedure of Grantly Dick Read." B. Sawyer. *Amer. Journ. Obstet. and Gynecol.*, June 1946, LI, 852-8.

66. "Moulding of the foetal head: a compensatory mechanism." J. Baxter. *Journ. Obstet. and Gynaecol. Brit. Emp.*, June 1946, LIII, 212-18.

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67. "Delivery after Cesarean section." F. A. Duckering. *Amer. Journ. Obstet. and Gynecol.*, May 1946, LI, 621-34.

68. "Le traitement des dystocias cervicales fonctionnelles par l'association anesthésique-ocytocique." (Treatment of functional cervical dystocia by anaesthesia and oxytocics.) P. Trillat and P. Magnin. *Gynéc. et Obstét.* (Paris), 1946, XLV, 144-5.

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72. "An enquiry into the causes of breech presentation." F. Tompkins. *Amer. Journ. Obstet. and Gynecol.*, May 1946, LI, 595-606.

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74. "A case of retained placenta, treated on conservative lines." M. Catchatoor. *Journ. Assoc. Med. Women in India*, February/May 1946, XXXIV, 8-9.

75. "Cas d'hémorragie incoercible de la délivrance après accouchement d'un foetus mort et macéré." (Uncontrollable haemorrhage after delivery of a macerated foetus.) A. Brindeau and J. Desoubry. *Gynéc. et Obstét.* (Paris), 1946, XLV, 73-5.

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77. "Acute inversion of the uterus." A. W. Spain. *Journ. Obstet. and Gynaecol. Brit. Emp.*, June 1946, LIII, 219-22.

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ANAESTHETICS

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LACTATION

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85. "Lactogenic properties of thyroid" (letter). J. D. Robertson. *Lancet*, June 29th, 1946, I, 978; Editorial 969.

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THE INFANT

GENERAL

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93. "Hepatic abscess complicating atresia of the small intestine of a newborn infant." S. Price and T. Chang. *Arch. Path.*, April 1946, XLI, 450-3.

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103. "Progress in pediatrics: coronary occlusive disease in infants and children." W. A. Stryker. *Amer. Journ. Dis. Childr.*, March 1946, LXXI, 280-300

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T. WATTS EDEN

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Obituary

T. WATTS EDEN

M.D., F.R.C.P., F.R.C.S., F.R.C.O.G.

*Chairman, Board of Directors, The Journal of Obstetrics and Gynaecology
of the British Empire Publishing Co., Ltd., 1930-1946.*

DR. EDEN'S connexion with our Journal was a long and intimate one. He contributed a characteristic Critical Review to the first volume published in 1902 and thereafter maintained the keenest interest in its progress. He served at various times as a member of the Editorial Committee and edited the Journal for two years, 1904-5.

Having joined the Board of Directors in 1920, he was elected Chairman ten years later and continued in that office until his death. During this long period of sixteen years he guided the policy of the Journal with a sure hand and in taking leave of him and placing on record their appreciation of his services, his colleagues on the Board are very conscious that they have lost a Chairman whom it will be difficult, if not impossible, to replace.

DANIEL DOUGAL

THOMAS WATTS EDEN was born in 1864 the son of Alfred Thomas Eden, of Evesham. He was educated privately and at the University of Edinburgh, where he graduated M.B. in 1888. In his student days he was marked for his piety and his power of rhetoric. He was a brilliant student, gaining many prizes and graduating with first class honours. In addition he gained the much-coveted Ettles Scholarship, awarded to the most distinguished graduate of his year, and the James Scott Scholarship for the greatest proficiency in Midwifery and Gynaecology. He was well-loved by his fellow students and made friendships which continued throughout his life.

In 1889 he was awarded the Leckie Mactier fellowship of Edinburgh University and used this to complete his equipment for a distinguished career by study in London, Berlin, Leipzig and Birmingham. In 1891 he proceeded M.D., again with honours, and later added the Fellowship of the Royal College of Physicians of London and of the Royal College of Surgeons, Edinburgh to his distinctions. He first joined the staff of the Chelsea Hospital for Women in 1898 as a resident surgical officer and later as

assistant surgeon. His first published paper in 1896 was a "Study of the Human Placenta", which attracted considerable notice. He continued to devote all his energies to his speciality and in 1906, when he was on the Staff of Charing Cross Hospital, Queen Charlotte's Hospital, and the Chelsea Hospital for Women, he published his *Manual of Midwifery* and displayed his great gifts as a teacher. Among his colleagues at his three hospitals were such men as Fairbairn, Gow, Comyns Berkeley and Victor Bonny. Teaching was his great love and he attracted many students to his clinic at Charing Cross Hospital.

He was examiner for the Conjoint Board and to the Universities of Oxford, Cambridge, Edinburgh and Leeds, and students recall him as one of the small number of examiners who "teach as they examine." His influence upon medical teaching and the progress of midwifery in this country was therefore great. He was one of the first to preach the concept of labour as a surgical matter than as a medical procedure.

During the first World War he served as a major in the R.A.M.C.

He was concerned in the foundation of the Royal College of Obstetricians and Gynaecologists in 1929, being a Founder Fellow, and Member of the First Council. He was also President of the Section of Obstetrics and Gynaecology of the Royal Society of Medicine, and in 1930 became President of the Royal Society of Medicine itself, being only the second obstetrician to fill this position since the inception of the Society.

He also served on the Governing Body of the British Postgraduate Medical School. At the time of its foundation in 1935, as a member of the Joint Council of the National Birthday Trust, he was one of the committee which in that year drew up a scheme for a National Midwives Service designed to improve the status and training of the midwife.

Dr. Eden's best known work is his *Manual of Midwifery*, which has gone through seven editions. In 1911 he wrote a *Manual of Gynaecology* and in 1916, in collaboration with Mr. Cuthbert Lockyer, his colleague at the Charing Cross Hospital, he wrote the monumental *Gynaecology for Students and Practitioners* which went to four editions.

Early in its career, he became a Director of *The Journal of Obstetrics and Gynaecology* of the British Empire, and continued to serve it as Chairman of the Editorial Committee until the time of his death.

Until the end of his life, although in retirement in Devon, he continued to serve the ideals of his profession on many committees, bringing to his work, dignity, moral courage, integrity and profound commonsense which commanded the respect and affection of all who worked with him.

His modesty and wisdom were reflected in his writings and his life, and his death leaves a sad gap in the affections of his many friends and colleagues.

In 1900 Dr. Eden married Miss May Bain of Cockermouth, who survives him.

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NEW SERIES

DECEMBER, 1946

The Use of Radiology in Predicting Difficult Labour*

BY

J. CHASSAR MOIR, M.A., M.D., F.R.C.S.E., F.R.C.O.G.

Nuffield Professor of Obstetrics and Gynaecology, University of Oxford.

LECTURE I: Introduction; Technical Considerations in Pelvimetry and Cephalometry.

INTRODUCTION.

AFTER paying tribute to Dr. J. T. Ingleby, physician and accoucheur in Birmingham in the earlier part of the eighteenth century, and comparing the incidence and importance of pelvic contractions in his day and in this, the lecturer proceeded as follows:

Nine years ago, when the Nuffield Unit of Obstetrics and Gynaecology was founded in Oxford, the opportunity arose of undertaking a comprehensive investigation of the value of radiology in forecasting the course of labour, and to this end, I was able to have incorporated in the new labour ward suite a self-contained X-ray room of generous size. Hitherto, it seemed to me, the use of radiology for antenatal and intranatal diagnosis had suffered from two faults; firstly, there had too often been a lack of co-operation between the radiologist and obstetrician so that neither fully appreciated the needs and difficulties of the other; and secondly, there was—and, I

believe, still is—too much reliance placed on what might be termed an impressionistic interpretation of the radiograph, with opinions based on general appearances rather than on precise data concerning the dimensions of the maternal pelvis on the one hand and of the foetal head on the other. On these lines there was little hope of scientific progress, nor was it possible for the methods, such as they were, to be adequately explained in writing or easily taught by word of mouth.

In this investigation I resolved to undertake the technical side of the radiological work myself—not because I consider that obstetricians in general should so engage, but because I wished to make a serious study of the various methods of pelvimetry and to learn for myself their relative merits and the possible sources of error. Moreover, in the proposed experimental work it was necessary to know beyond doubt that the radiographs were secured with the patients correctly positioned and with the necessary adjustments accurately made. Nearly 800 patients have now passed through my hands, and although the combined rôle of radiologist and obstetrician has been heavy, it has enormously added

* The first of two Ingleby Lectures delivered at the University of Birmingham, May 1946. The second lecture, "Forecasting the course of labour," will appear in the next issue of the *Journal*.

to the interest and, I believe, to the value of the work. It has also enabled me to develop several small but useful modifications to the standard method of pelvimetry which will presently be described.

I now welcome this opportunity of presenting an account of this long-term research and, particularly, of placing before you, for what it is worth, a new system by which the obstetric value of the pelvis may be assessed with relative ease and with a fair degree of accuracy.

TECHNICAL CONSIDERATIONS.

To discuss in detail the various radiological methods of pelvic examination* is beyond the scope of these lectures nor is it possible to do more than acknowledge the magnificent work of Caldwell and Moloy⁸, D'Esopo¹⁰ and others on the variations of pelvic formation and their significance. It is enough to say of 3 or 4 reliable systems of pelvimetry I have no doubt that for routine work in a busy hospital the isometric method—associated particularly with the name of Herbert Thoms⁷ of New Haven—is the first choice. In it a scale is incorporated in each film so that the obstetrician himself can measure what he will, and can do so without need for arithmetical calculation or reference to correction tables. Moreover, as will be shown, certain simple pieces of apparatus can be constructed, and fixtures added to the X-ray plant, by which the taking of the films is greatly simplified. The methods are these.

Lateral projection. The lateral view of the pelvis is by far the most important of any single radiological examination, both on its own account, and because information gained enables the patient to be correctly positioned for subsequent examinations.

The radiograph is obtained with the patient standing erect, and with the X-ray tube at not less than 4 feet range from the film. If a stationary (Lysholm) grid is used, 4 feet 3 inches is a convenient distance; if the thicker Potter-Bucky grid is used 4 feet 6 inches should be the minimum. I have found it possible to simplify the technique by attaching to the upright screening stand two movable wooden pegs against which the patient presses her anterior superior iliac spines. One of these pegs is attached to, and moves up and down with, the film-cassette holder; the other has an independent vertical movement to suit the height of the patient (Fig. 1); the precise size and position of

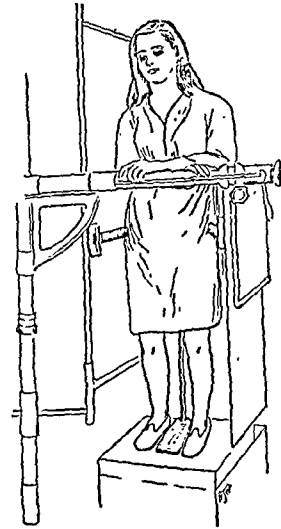


FIG. 1.
Position for lateral pelvimetry showing the pegs against which the patient presses her anterior-superior iliac spines (see text).

the pegs have in the first instance been carefully calculated to ensure the correct positioning of the average patient. By this simple expedient three of the bugbears of lateral radiography are at once eliminated: the patient assumes the true lateral position, she remains motionless during exposure, and the X-ray tube is automatically positioned over a selected centre of the pelvis (ideally the spines of the ischium). There is the further advantage that, with the patient immobilized, the milliamperage may be reduced and exposure prolonged, thus greatly lessening the strain on the tube. After positioning, a metal rod mounted on a firm stand is placed between the patient's legs

* See references, 1, 2, 3, 4, 5, 6, 7, 8 and 9.



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PLATE I.

Lateral pelvimetry, showing measuring-rod in position.

C. M.

Acknowledgment is made to Messrs. Baillière, Tindall & Cox for permission to reproduce Figures 1, 2, 3, 4, 6, and Plates I, II, III, V, VI, VII, VIII and IX from the new edition of Munro Kerr's *Operative Obstetrics*, now in the press.

so that a centimetre measure rests alongside the cleft of the buttocks. A scale equally magnified with the pelvis in the sagittal plane is thus impressed on the resulting film (Plate I).

If the patient has been correctly positioned the resulting radiograph should show two acetabulae nearly superimposed, and the spines of the ischium quite superimposed. The erect standing posture makes exact positioning much easier, for a sideways tilting of the pelvis—a common fault in lateral radiography—is thereby reduced to a minimum. Even if the patient is in labour she can usually be encouraged to stand; but if that is not possible, use can

sacrum; (6) the size and shape of the sacro-sciatic notch; (7) the length of the lower antero-posterior diameter (from the lower inner margin of the pubic symphysis to the tip of the sacrum); (8) the length of the posterior sagittal diameter of the outlet (from the midpoint of a line joining the ischial tuberosities to the tip of the sacrum).

Supero-inferior projection. A second picture is a supero-inferior, or "plan", view of the pelvic inlet, and is obtained by placing the patient on the X-ray table in a reclining position (Fig. 2).

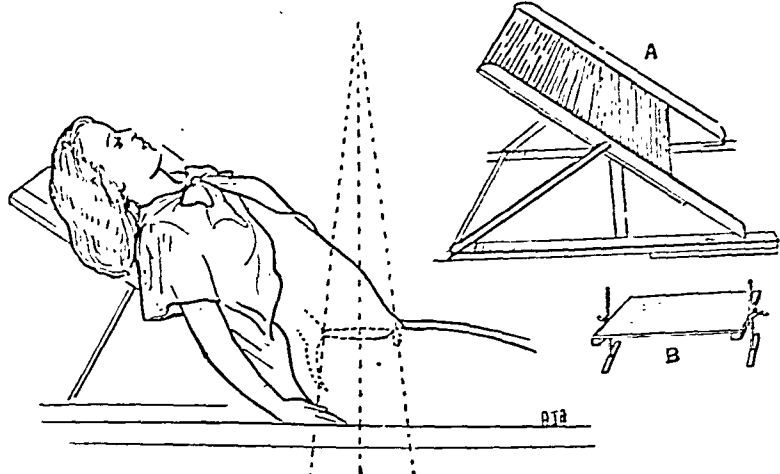


FIG. 2.
Position for supero-inferior projection pelvimetry

be made of a positioning apparatus similar to that already described, but adapted for the horizontal lateral position.

The lateral picture gives exact information of the brim conjugate which no other view can give. It also shows: (1) the true, and the false promontory (if present); (2) the inclination of the pelvic brim; (3) the relation of the foetal head to the brim, and the degree of the engagement; (4) the bi-parietal diameter, or some other diameter from which the bi-parietal may be estimated; (5) the length and shape of the

This method of obtaining the outline of the pelvic brim is well established, but unless precautions are taken to ensure that the plane of the brim is parallel to the table (or, alternatively, that suitable compensation is made for any angulation, as in Thoms's original method), results may be misleading. It is often stated that the patient has been correctly positioned if in the resulting picture the superior and inferior pubic rami are superimposed, thus obliterating any view of the obturator foramina. In general, this is true, but there are types of pelves whose conformation is such that the superior and inferior rami do not become superimposed even with correct positioning; this is seen especially when there is a wide pubic arch. The

pelvic brim is usually rendered parallel, or nearly parallel, to the table when the back-rest is at an angle of 35 degrees, and the patient's lumbar region is in a position of lordosis.

For greater accuracy the following method has been developed. When the previous lateral radiograph was made, a small metal marker was fixed to the skin over the sacrum at the approximate level of the posterior superior iliac spines; in the resulting picture the angle formed by the lines joining the upper margin of the symphysis pubis to the marker on the one side, and to the posterior extremity of the brim on the other, was measured. A series of half-circle wire hoops is now at hand; each hoop is shaped to touch the skin marker behind, and the upper border of the symphysis pubes in front

40 inches distant from the film (I use 47 inches) and centred $2\frac{1}{2}$ inches posterior to the upper margin of the symphysis pubis. After the exposure the patient leaves the table and the scale is impressed on the film in the following manner. A thin lead sheet, perforated at centimetre intervals, is placed above the table at a height corresponding with the position previously occupied by the brim of the pelvis. (This height is conveniently determined at the time of the first exposure by recording with a drop-line the distance from the X-ray tube to the upper border of the symphysis, allowing for any table-sag caused by the patient's weight.) A second flash exposure is now made, and the centimetre marks, correctly magnified, are thus superimposed on the film (Plate II).

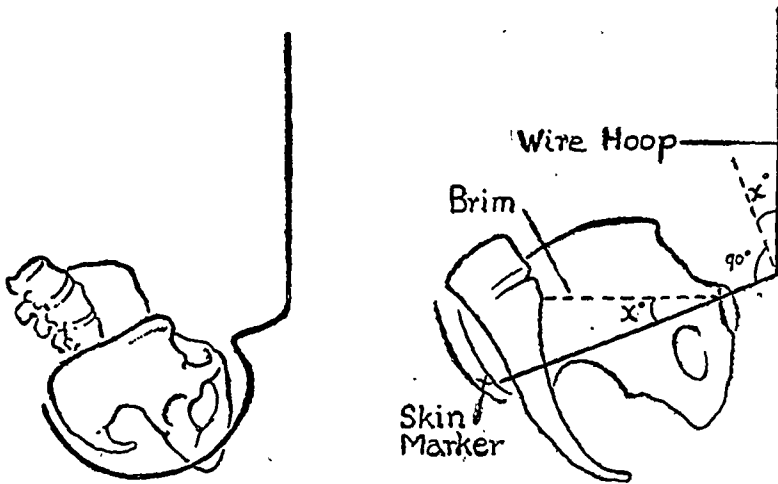
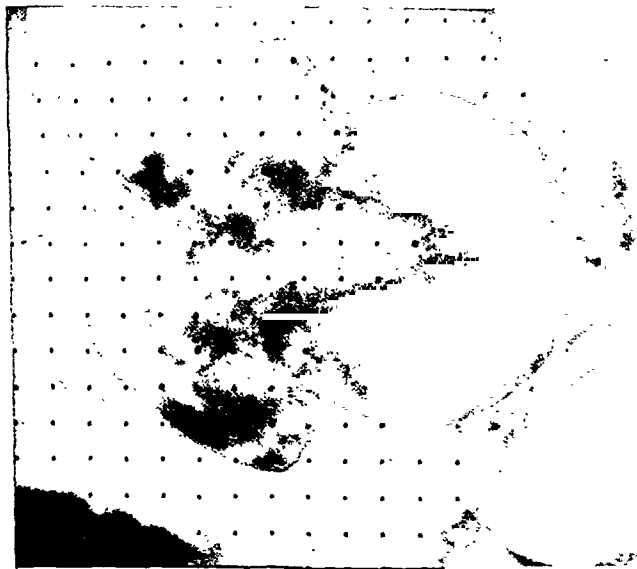


FIG. 3.
Diagram illustrating the use of the half-circle wire hoop to ensure that the pelvic brim is rendered parallel to the top of the radiographic table (see text).

From the front of the hoop an arm extends upwards making an angle with the vertical which, in different hoops, varies from 10 to 35 degrees. When the supero-inferior radiograph is to be made, the hoop with an angle corresponding to the angle previously measured on the lateral radiograph is selected, and is applied to the points mentioned; the patient—or, more accurately, the patient's pelvis—is then positioned until the arm of the wire hoop points vertically upwards. With the pelvis in this position the brim is necessarily rendered parallel to the table (Fig. 3).

The exposure is made with the tube at least

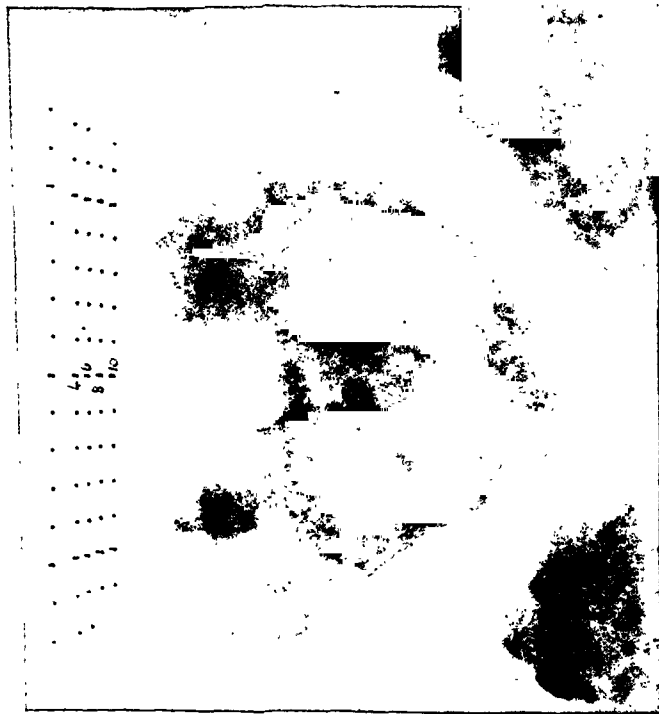
In recent years, Thoms¹¹ has slightly altered his method. As in the description given above, he now aims at positioning the patient so that the pelvic brim (and consequently also the perforated plate) is always parallel to the table top. Instead of the uniform centimetre scale, it now becomes possible to introduce a series of scales (Plate III). One of these is a true centimetre scale and is used as before for the measurement of the brim. When, however, landmarks at levels below the brim



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PLATE II.

Example of supero-inferior projection pelvimetry.
(In this case there is markedly "anthropoid" brim.)
C. M.



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PLATE III.

Example of supero-inferior projection pelvimetry showing the use
of the multiple scale. (In this case the brim is markedly wedge-
shaped.)
C. M.

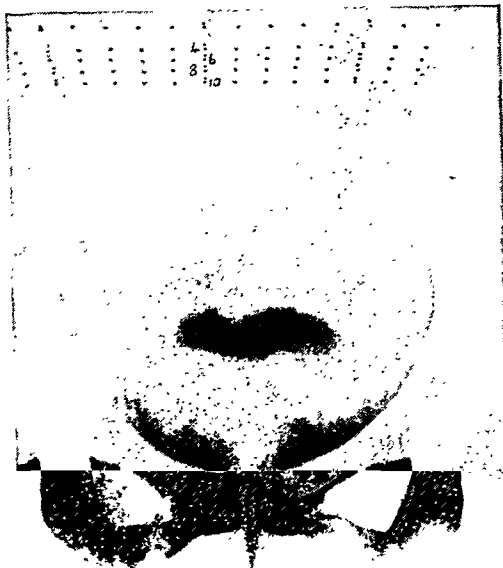


PLATE IV.

Modified position for measuring, in a patient at term, the available transverse diameter of the brim, and the bi-spinous diameter.

C. M.

are to be measured—for example, the bi-spinous diameter—the difference in level from the brim must first be determined by reference to the lateral radiograph, whereupon the appropriate supplementary or “corrected centimetre” scale* shown in the supero-inferior radiograph can be selected for the measurement in hand. The method removes the necessity for mathematical calculation or reference to correction tables, and it thus greatly reduces the work necessary for obtaining the measurements from the film. It has definite advantages over Thoms’s earlier technique.

Modification for patients at term. If the woman is near term, the radiograph obtained by the above method tends to be of poor quality; although the brim can be discerned, the ischial spines—important landmarks—are usually obscured. Better pictures are obtained if the patient is examined in the dorsal position with a pad under the small of the back to cause lordosis. In this position the ischial spines are more easily identified and the bi-spinous diameter measured, although the shape of the brim is lost because of the considerable foreshortening of its antero-posterior dimensions (Plate IV). This disadvantage is however not so grave as might be supposed, for, by calculation, the particular transverse diameter which has most obstetric significance—the *Available Transverse* as I like to call it—can still be measured with fair accuracy. This is the diameter that intersects the conjugate at mid-point; its significance will be discussed in a later section.

When the patient is in the dorsal position the measurement of any brim diameter is a difficult mat-

ter. The available transverse diameter is identifiable only because of the fortunate finding that its position very closely corresponds with that of a line joining points 2 mm. posterior to the posterior acetabular margins. A small correction is necessary if the posterior sagittal diameter is unusually short (the so-called “android”, or wedge-shaped brim), or unusually long. Both these conditions can be diagnosed from the lateral radiograph by noting the position of the posterior margins of the acetabular cups relative to the sacrum—near in the one case and distant in the other. In the

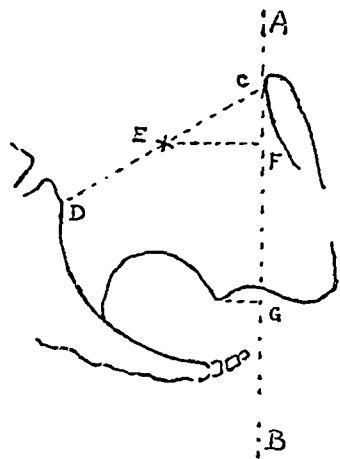


FIG. 4.

Method of measuring the depth of the available transverse diameter of the brim from the top of the pubes, and hence from the level of the scales.

AB is drawn to mark the position of the tip of the coccyx relative to the symphysis pubis as seen in the antero-posterior radiograph. From mid-point E of the conjugate CD a line EF is drawn vertical to AB. CF then gives the required measurement.

former, the available transverse diameter occupies a position 2 or even 3 mm. further forward than the position above stated, and in the latter it is 2 or even 3 mm. further back. The scale is introduced as in the standard method. The measurement of the level of this diameter below the top of the pubis (and hence below the level of the scale) is explained in connexion with Fig. 4. No claim of high accuracy can be made when this rough and empirical method is used; nevertheless, when the measurements obtained by the two techniques of brim pelvimetry are compared it is seldom that a discrepancy of as much as 2 or 3 per cent is

* The supplementary scales are plotted in the first place by dummy experiment; once made they are sufficiently accurate for all ordinary clinical use so long as a constant target-film range is employed.

encountered. In practice, the information given by the second method is therefore usually sufficient for the purpose in hand.

There is another objection to the use of the standard method when pregnancy is far advanced. When the patient is placed in the reclining position the fundus of the uterus is, relative to the pelvis, very close to the X-ray tube. Now, since the intensity of radiation varies inversely with the square of the distance, it follows that the foetal part occupying the uterine fundus—normally the breech—receives an excessively heavy exposure, and one which, for all we know, may be harmful to the foetus. This is avoided by the modification described.

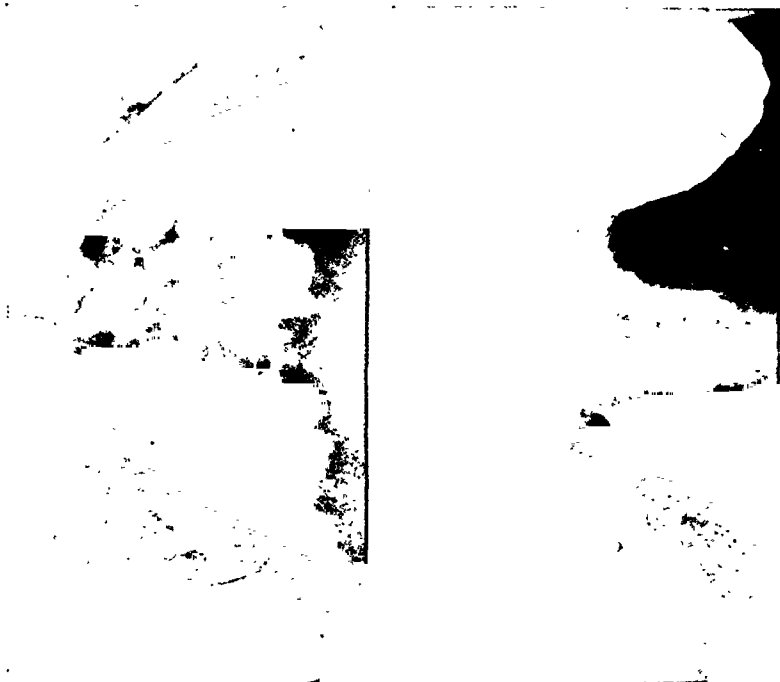
Pubic arch measurement. The third picture concerns the pubic arch. In the usual antero-posterior view of the pelvis the shadow of the arch is greatly foreshortened, and its measurement is then little more than guesswork. In the Chasard-Lapine¹² technique the patient sits on the film cassette and bends well forward while the tube is centred vertically over the ischial tuberosities. By this means the pubic arch is made to lie approximately parallel to the film, and distortion is almost eliminated.

The following modification has been evolved which is more convenient for the pregnant woman. The patient sits on a specially constructed box in which there is an oblique slot to hold a cassette for 6 × 4 inch-size film (Plate V). Matters are so arranged that when she assumes a comfortable sitting posture the ischial tuberosities slide into a groove, thus correctly positioning the pelvis and, at the same time, ensuring that the pubic arch lies approximately parallel to the plane of the film. If desired, the patient can be still more accurately positioned by an adaption of the marker technique already described; but in practice this has not been found necessary. Exposure is made from behind, with the X-ray tube obliquely tilted so that its rays impinge on the film at a right

angle. The smallest possible diaphragm is used in the X-ray tube to obviate the need of using a stationary grid to cover the film (Plates VI and VII).

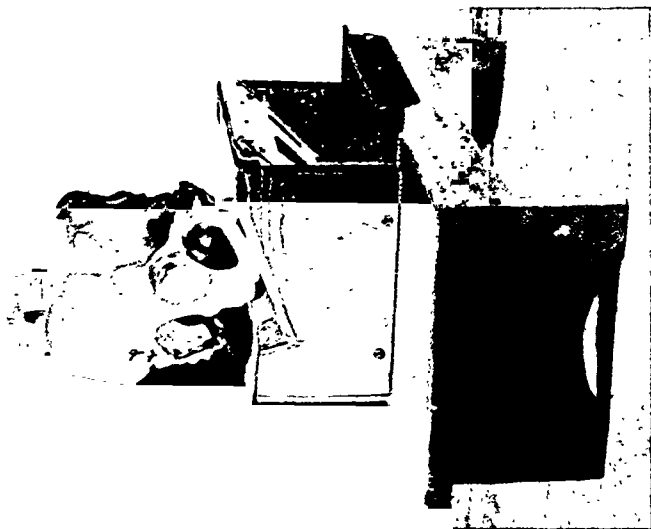
There are various ways of measuring the radiograph of the arch. The most obvious is to measure the distance between the ischial tuberosities. Unfortunately, these points are indefinite, and some arbitrary means must therefore be adopted for their identification; thus, Rohan Williams recommends measuring from the lateral margins of the obturator foramina. Another method is to place a circular disc, representing the size of the foetal head, in the span of the arch, and then to measure the wasted space between the foetal head and the lower border of the symphysis pubis; by this means a useful indication is obtained of the obstetric value of the arch. This method has been tried in the Oxford investigations, and has also been developed independently by Dewar of Dumfries, and Morris and Whittaker of Ayr. The simplest method is to measure the arch-angle. Unfortunately, the limbs of the arch are often curved and this has led to varying definitions of the arch-angle by different workers. In my own work I have adopted the definition urged by Nicholson. The lower border of the symphysis is identified, and a spot selected exactly between the two pubic bones; from this point lines are drawn to touch the pubic rami where they project furthest inwards—usually in the neighbourhood of the ischial tuberosities. The angle between those lines is then measured.

Summary. By those 3 radiographs all the important pelvic measurements can be determined. In each picture the need for arithmetical calculation has been eliminated; the methods are, in short, devised to reduce the examination to the simplest possible form compatible with the accur-



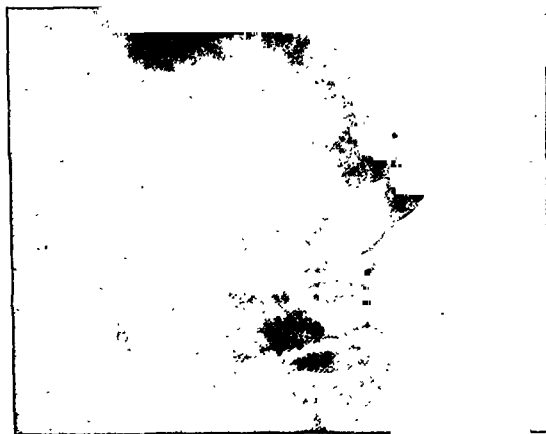
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PLATES VI and VII.
 Examples of pubic arch pelvimetry.

C. M.



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PLATE V.
 Special stool for pubic arch pelvimetry, showing
 position assumed by the pelvis.

C. M.



Baillière, Tindall & Cox

PLATE VIII.

Example of cephalometry in the case of a breech presentation.

C. M.

acy required for clinical work. Here it may be added that there is evidence that the pelvic dimensions themselves vary slightly according to the position of the patient, for example, whether erect or recumbent, and it is therefore important that the technique used should be constant.

Time of examination. The examinations are best made in the last weeks of pregnancy, partly because it is unwise to subject an early embryo to heavy and repeated radiation, and partly because the size of the foetal head and its relationship to the brim can then be estimated. In the post-natal period pelvimetry may again be of value, for an explanation may then be forthcoming for some unexpected difficulty that has arisen during the course of labour, and the information so obtained may give material help in deciding treatment on a future occasion.

CEPHALOMETRY.

Thus far pelvimetry only has been considered; let us now turn to cephalometry. Obstetric disproportion means an unfavourable relationship of the foetal head to the maternal pelvis, and it is therefore illogical to study the one without the other. Now, in size, shape and plasticity, foetal heads vary to a surprising extent. Further, the foetal head is an awkward object to measure by X-rays, particularly as it sometimes lies free above the brim and inclined to one or other iliac fossa. But the difficulties are not so great as to make cephalometry worthless; and although precision cannot always be attained, it is usually possible to state a measurement below which the shortest diameter of the skull (the suboccipito-bregmatic, or the biparietal) must lie. This in itself is information of considerable value.

The shortest diameter of the skull is chosen for this work because, as pointed out by Reece,³ it is the one always seen on

the radiograph, whereas the longest diameter is revealed only if the long axis of the head happens to lie at right angles to the direction of the rays.* The measurement is generally obtained from the lateral picture, but if the view of the head is unsatisfactory, help may also be obtained from examination of the supero-inferior picture of the pelvic brim, allowance being made for any difference of level of the required diameter of the head from the level of the centimetre scale. In the case of a breech presentation, cephalometry is conveniently made with the patient standing erect, and with the tube at 4 feet 6 inches distance from the film. The abdomen is palpated and the patient positioned to bring the foetal head into a "tangential" position; the patient herself then holds the centimetre measure directly over the mid point of the head (Plate VIII).

If the biparietal diameter can be clearly seen—and very often it is—one is safe in stating its measurement. Next best is the suboccipito-bregmatic diameter. If, however, an oblique diameter only is visible, one is left in some uncertainty regarding the size of the head, and all that can be said is that the biparietal diameter will be *less* than the visible shortest diameter. Exceptions to this are very few. Reece assumes that the biparietal and the suboccipito-bregmatic diameters are equal. In a long series of measurements I have found that this is not invariably true; sometimes—especially in the case of soft skulls—the suboccipito-bregmatic is greater than the biparietal diameter (rarely by as much as 5 millimetres); while sometimes—especially in the case of well-ossified skulls—there are decided parietal bosses causing the bi-parietal to exceed the suboccipito-bregmatic diameter (again rarely by as much as 5 millimetres). For the present purpose it is unfortunate that there should be any uncertainty about these measurements; but there does not appear to be any other simpler method of

* Compare the shadow of an egg. The long axis is shown only when the egg is in a certain position, the shortest diameter is shown in every position.

cephalometry, and we must therefore continue to use the bi-parietal diameter as the best available indicator of head size.

In my work I have, so far as possible, always checked the radiographic estimation of head size by clinical measurement after birth, and after moulding has passed off. Measurement is made by lightly grasping the head from side to side and measuring the bi-parietal diameter with engineers' callipers; the span is then read off on a ruler. Obstetric callipers are much too inaccurate for this work. Personal measurement is necessary, for different observers may not agree to within 1, 2,

and Calkin¹³ state that this averages 2.5 mm. ($\frac{1}{10}$ of an inch) per week. My own practice is to allow 2 mm. per week. I am influenced in selecting this smaller figure because of the observed rate of growth of the infant's head in the neonatal period (Fig. 5).

Moulding of the head. Moulding of the head is, of course, a matter of highest importance. When the head is measured at birth, and again 24 hours later, it is usual to find that the biparietal diameter

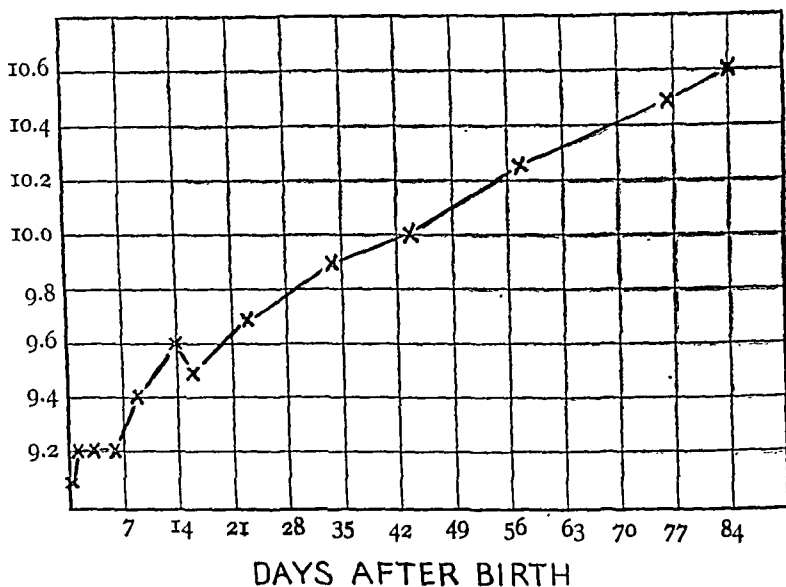


FIG. 5.

Growth of an infant's head after birth (bi-parietal diameter in centimetres). The slight irregularity on the 14th day was presumably caused by an error in measurement.

or even more millimetres of the exact dimension. This is partly because of the inconstant pressure applied to the head, which will, in the case of a soft mouldable head, appreciably alter the readings.

Growth of the foetal head. If radiographic examination has been made before term, it is necessary to allow for the subsequent growth of the head. Scammons

has increased by 1 or 2 millimetres. Sometimes the difference may be 4, 5, or even more millimetres; but in these cases the head is less well ossified than normal, and can be readily altered in shape even by finger pressure (Plate IX).

This matter of moulding is held by some to nullify the value of cephalometry and to frustrate any serious attempt at predict-



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PLATE IX.

Left: Moulding of an infant's head half an hour after delivery. Right: The same infant 3 days later. (The skin outline, lost in reproduction, is indicated by dotted lines.)

C. M.

ing the course of labour. I do not agree with these sweeping statements. It is common knowledge that good moulding will greatly facilitate the progress of labour in a case of borderline disproportion. But there is another side to the question. While moulding will at times enable a seemingly impossible obstacle to be overcome, remarkable happenings of

revealing pelvic type, radiology will often indicate when moulding will, and when it will not, be an effective factor. Again, moulding is safe only when it is moderate in degree; and there is a point beyond which it endangers the foetal life. It is often effective in the case of the small foetus, but is less effective or safe in the case of the post-mature foetus with a well-

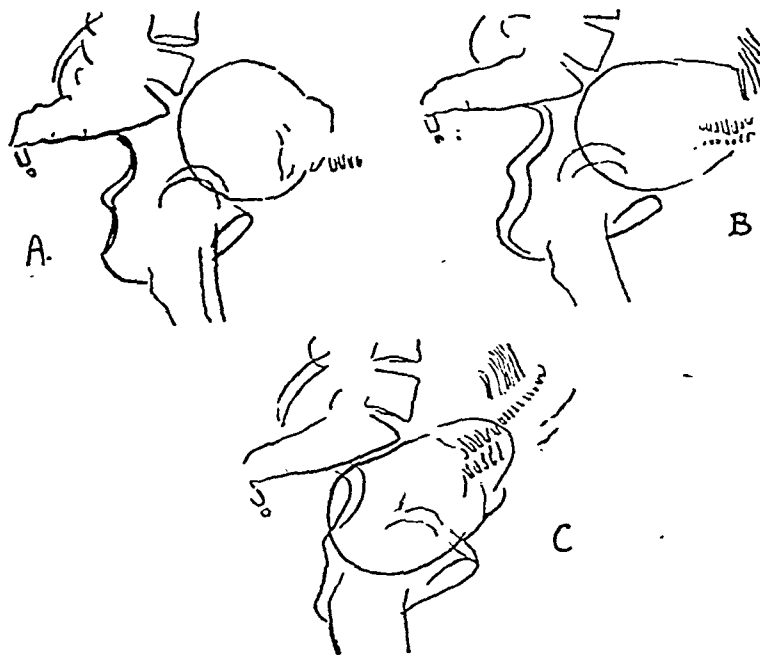


FIG. 6.

Tracings of radiographs showing progress of labour in a rachitic flat pelvis with obstetric conjugate of 8.3 cm. (3.3 in.).

A. Before labour. B. Early in labour (11 a.m.). C. Late in labour (3.30 p.m.). Delivery was spontaneous after a labour of 22 hours. The baby weighed 6 lb. 11 oz., the bi-parietal diameter measured (approximately) 8.8 cm.

this nature are encountered almost exclusively in connexion with a pelvis that is contracted in but one dimension, as for example, the rachitic pelvis with its flat brim (Fig. 6). Moulding is not so conspicuously effective in enabling the resistance offered by the generally-contracted pelvis to be overcome. Now, by the

ossified head, or with a biparietal diameter of 9.5 cm. or more. To some extent, the degree of danger likewise depends on pelvic type, being least in the rachitic with its one-dimensional compression, and most in the generally-contracted pelvis with its circumferential compression.

When one attempts to predict the course

of labour one assumes that reasonable moulding will take place; but for the reasons stated it is unwise to rely on a reduction of more than 2 or 3 millimetres in any dimension. In doubtful cases it is an advantage to repeat the lateral examination during labour and to observe the degree of moulding attained. But caution must be observed; safe delivery for the mother does not necessarily mean safe delivery for the baby, and foetal death may result from protracted labour even if delivery is spontaneous.

ADDENDUM.

A Comment on a Recent Criticism of Brim Pelvimetry.

A comprehensive experimental study of radiological pelvimetry has recently been made by O. S. Heyns¹⁴ of Johannesburg. His paper covers a great deal of ground and is an important, if controversial, contribution to the subject. His findings are of great interest and many of them will be generally accepted; some of his statements, however, I have not been able to confirm.

Heyns states that the "brim" outline shown in supero-inferior radiographic projection does not represent the true anatomical brim, but the outline of the pelvic wall as some indefinite distance below the brim. This applies to the lateral walls which, in consequence, represent no particular anatomical landmark and are therefore of little value for measuring the transverse diameter. ("... the greatest transverse diameter of the brim cannot be found, and we submit that it is not possible by any method, stereoscopic or otherwise." Also: "the greatest transverse of the brim obtained from A.P. films is in the region of 7.5 mm. shorter than on the pelvis, the range being from 5 to 10 mm.")

If Heyns's contention is correct it seriously undermines the basis of the second method of pelvimetry, and makes the radiographic measurement of the important transverse diameter a highly uncertain procedure.

In my early experimental work I compared the stereoscopic pelvimetry with isometric

pelvimetry and became aware of the fallacy which Heyns now stresses. I was, however, satisfied that the difference between the transverse diameter as shown in supero-inferior projection and the transverse diameter found on actual measurement of the dried pelvis was too small to be of practical importance. In view of Heyns's findings it was necessary to investigate this matter afresh. Using all the dried pelves available to me (eight) I attached a series of lead shot around the anatomical brim and photographed the pelvis according to the method described in this paper. The difference between the transverse measurement as determined by the position of the shot, and the transverse measurement as determined by the radiographic appearance of the brim margin was in some cases barely measurable; in others it was definite, but in no case did it amount to as much as 2 millimetres. This applied also to the comparison of the radiographic with the direct pelvimetry measurements (Plate X).

I am therefore at a loss to explain why Heyns should find such a considerable discrepancy between the radiographic and the true transverse diameter. The small discrepancy which is certainly present will, of course, become magnified the nearer the tube is brought to the pelvis. In my work I use a standard tube-film distance of 47 inches, and anything appreciably shorter than this is, in my opinion, undesirable. Heyns appears to use a distance of 40 inches, which may give a partial explanation of his different findings. But another explanation is possible: Heyns may select, as the outline of the brim, the innermost margin of any bone outline seen on the film. This, however, would be unreasonable, for care must always be taken to identify the brim margin as it leaves the sacrum and to follow its curve as it crosses the bone mass of the ischium with its projecting spines.

Heyns is also severe in criticism of certain other matters pertaining to the Thoms's technique; for example, Thoms's proposal to measure the depth of the ischial spines from the brim-level by use of lateral pelvimetry. While accepting the theoretical basis of the criticism, I do not concede that an uncertainty affecting the subsequent reckoning of the required diameter to the extent of a 1 or 2 per cent error need invalidate a method of pelvi-

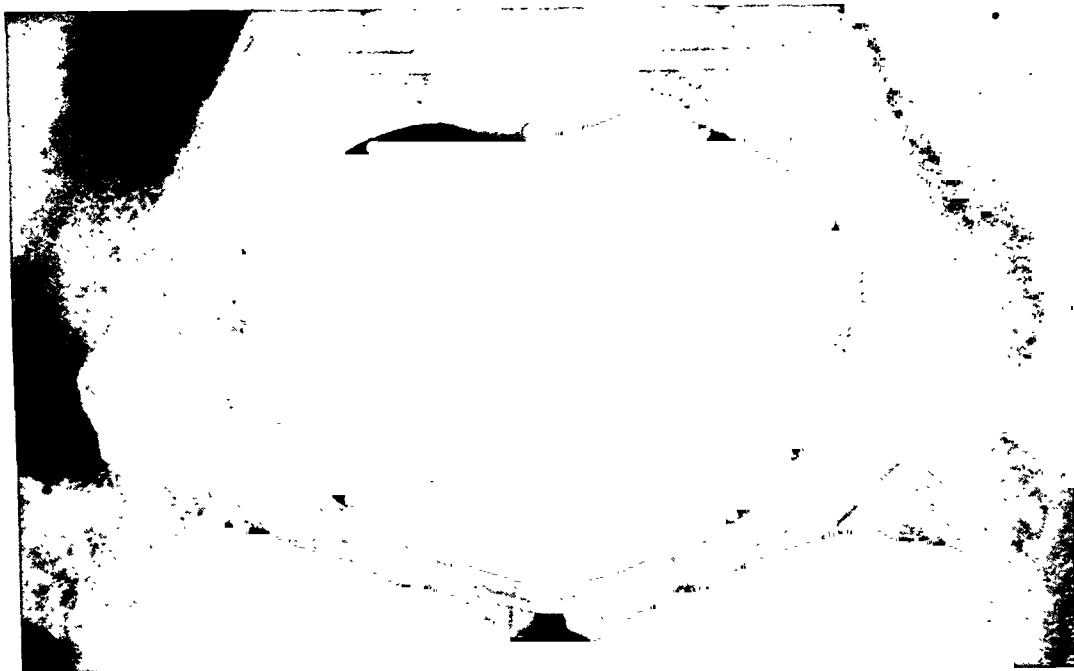


PLATE X.

Radiograph of a dried pelvis showing the close correspondence between the radiographic outline of the lateral portions of the brim and the anatomical brim outline as indicated by the position of the lead shot.

C. M.

metry which has the other great advantages of simplicity and convenience. So, too, with the criticism of the radiographic measurement of the pubo-sacral diameter and the alleged uncertainty of locating its anterior end-point. The lower antero-posterior diameter (as it has been called in this paper) and its end-points have already been defined. Only on rare occasions have I found any difficulty in locating the anterior end-point on the radiograph, and then any error has probably been well within the range of ± 2 mm. In experiments on the dried pelvis this point has been located with a margin of error of less than ± 1 mm.

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The Nutrition of Expectant and Nursing Mothers in Relation to Maternal and Infant Mortality and Morbidity

(The People's League of Health)

In July 1935 the People's League of Health appointed a special committee to consider the influence of the nutrition of expectant and nursing mothers on maternal and infant mortality and morbidity. The Committee consisted of: Professor James Young (British Postgraduate Medical School), Chairman; Miss Margaret Basden (Mothers' Hospital, Salvation Army); Professor F. J. Browne (University College Hospital); Professor Amy Fleming (Royal Free Hospital); Dame Louise McIlroy (Thorpe Coombe Maternity Hospital); W. C. W. Nixon (St. Mary Abbots Hospital, L.C.C.), Medical Secretary; W. H. F. Oxley (East End Maternity Hospital); L. Carnac Rivett (Queen Charlotte's Hospital) and James Wyatt (St. Thomas's Hospital); and the following: H. Davis, P.H.D., P.H.C. (Pharmacist, U.C.H.); Professor J. C. (now Sir Jack) Drummond (Professor of Biochemistry, University College, London); Miss Letitia Fairfield, M.D. (Senior Medical Officer, L.C.C.); W. T. Russell, F.S.S. (Statistician, London School of Hygiene); Miss Jean Wishart, S.R.N. (Queen Mary's Maternity Home) and Miss Olga Nethersole (Founder and Honorary Organiser, People's League of Health).

The League had the co-operation of 10 London Hospitals: East End Maternity Hospital; Hammersmith Hospital (L.C.C.); Mothers' Hospital (Salvation Army); Queen Charlotte's Hospital; St. Mary Abbot's Hospital (L.C.C.); St. Thomas's Hospital; Thorpe Coombe Maternity Hospital; University College Hospital; Queen Mary's Maternity Home

(Hampstead) and the Royal Free Hospital.

Three commercial firms—Messrs. Vitamins, Ltd.; Crookes Laboratories and Roche Products Ltd.—supplied the vitamin and mineral elements required, free of charge.

The Committee issued an Interim Report in 1942, which was published in the *British Medical Journal*¹ and the *Lancet*.² The following paragraphs taken from that Report explain the objects and the nature of the investigation:

The main investigation, which was carried out from March 1938 to the end of 1939, was planned to show whether additions of vitamins and minerals to the food would benefit the course of pregnancy and labour and the newborn child. In order to obtain some information concerning the type of diet consumed by the group of women to be studied, an inquiry was made among expectant mothers attending four of the hospitals which collaborated in the test; these patients included some of the women enrolled in the investigation. It was not possible to make a detailed dietary survey, but nearly 1,000 women filled in questionnaires recording the food they had eaten during a week. This was at best a rough and ready method of assessing food consumption, but there were good reasons for believing that it would give some evidence of the nutritional level of the women during the experimental period. A scoring system was adopted by which arbitrary values were given to express the daily consumption of the more important foodstuffs, such as milk, butter, wholemeal bread, fresh vegetables, fatty fish, fruit, eggs, et cetera. By making a sum of the weekly score for appropriate foods, approximate estimates could be made of the intakes of first-class protein, vitamins, minerals, et cetera, while from a general summation a picture of the diet as a whole was obtained. This procedure was sufficient to reveal

any well-marked deficiencies in the diet. A somewhat similar scoring system has recently been found of great practical utility in nutritional investigations in Toronto.

Analysis of the records showed that, in general, there was no well-marked deficiency of first-class protein among any of the women answering the questionnaires. As regards minerals, a shortage of calcium was noted in about 70 per cent of the women, most of whom were consuming insufficient milk and cheese. Iron deficiency was even more serious, only 2 per cent of the women having a satisfactory intake. As regards vitamins, the deficiency of A was the most common, this being anticipated from comparison with other pre-war data. Rather more than half of the women were taking less vitamin A than they required. Generally speaking the diets were not badly defective in Vitamin B₁, but nearly half the women were not obtaining as high an intake as was really desirable. Vitamin C shortage also affected about half the women, but once again the deficiency was not nearly so great as had been expected. The general impression was that the women were on the average better nourished than had been expected from previous surveys of comparable groups of the ordinary population. Many of the women were clearly following advice given at the antenatal centres, and fresh fruit and eggs frequently entered into their daily diet. The same was true of milk. The women said they were taking these foods especially because they had been advised that the health of their babies would thereby be improved. There were, however, instances in which the dietaries were grossly defective.

The committee next decided on the amounts of vitamins and minerals required to make up the deficiencies noted. The daily supplements used for the experiment were:

Saccharated iron carbonate, gr. 18 (1.2 g.), equivalent to 0.26 g. ferrous iron.

Calcium lactate, gr. 30 (2 g.) equivalent to 0.26 g. calcium.

Minute quantities of iodine, manganese and copper. Adsorbate of vitamin B₁ containing all factors of the B complex (B₁ content standardized at 200 I.U. per g.) gr. 15 (1 g.).

Vitamin C (ascorbic acid), 100 mg.

Halibut liver oil (vitamin A, 52,000 I.U. per g. and vitamin D 2,500 I.U. per g.), min. 6 (0.36 g.).

It was decided that the investigation should include a minimum of 5,000 pregnant women to be enrolled at the antenatal clinics of the participating hospitals. All women attending at the clinics from the date of the commencement of the research were included with the exception of two groups. (a) Those whose pregnancy had advanced beyond the 24th week. This meant that in all cases there was an interval of 16 or more weeks between the commencement of the research and the date of delivery. (b) Women who suffered from any disease or physical abnormality.

In all 5,644 pregnant women were initially enrolled but of these only 5,022 remained in the investigation. The rejections were as follows:

(1) Withdrawals on account of war made up chiefly of women who were evacuated from the London area	494
(2) Women who had twin births ...	39
(3) Women who miscarried at an early stage	87
Total	622

In each hospital the women at the time of enrolment were divided into two main groups by placing them alternately on separate lists. In this way we attempted to equate the numbers and the age distribution. The women in one group received the supplements (treated), while those in the other served as controls (controls). Within each of these groups the women were further classified into (1) women pregnant for the first time and (2) women with a history of one or more previous pregnancies. Again each of these two groups were subdivided according to age: (a) women under 25; (b) women between 25 and 30 years; and (c) women over 30 years.

The extent to which we were successful in our sub-division is shown in Table I.

The slight divergence that has occurred is due to the slightly different numbers in the respective groups of the cases eliminated from the investigation for the reasons given above. The age distribution amongst the various groups is shown in Table I. It will be noted that the primiparae were mainly

Toxaemia According to Revised Standard.

Within recent years, and increasingly since the date at which this investigation was planned and the standard as given above was laid down, it has come to be recognized that a diagnosis of toxaemia cannot be based upon hypertension by

TABLE I.
Distribution by Age and Parity.

Age group	Primiparae				Multiparae			
	Treated		Controls		Treated		Controls	
	No.	per cent	No.	per cent	No.	per cent	No.	per cent
15-	90	5.9	84	5.6	8	0.9	9	0.9
20-	514	33.6	527	34.8	142	14.5	168	16.8
25-	633	41.4	623	41.2	371	37.9	349	34.9
30-	226	14.8	220	14.5	282	28.8	286	28.6
35-	63	4.1	54	3.6	139	14.2	151	15.1
40-	4	0.3	5	0.3	38	3.9	36	3.6
All ages	1530	100	1513	100	980	100	999	100

under age 30 (80 per cent), whilst the multiparae were equally distributed above and below this age. The total women available for the investigation were distributed as follows:

		Treated	Controls	Total
Primiparae	...	1530	1513	3043
Multiparae	...	980	999	1979
		2510	2512	5022

THE MOTHER.

TOXAEMIA.

At the start of the research it was decided to regard as toxaemia (a) cases which exhibited hypertension—a systolic blood-pressure of or above 140 mm. Hg. or a diastolic pressure of or above 90 mm. Hg.—with or without albuminuria, and (b) cases in which there was no hypertension and in which the diagnosis was based upon albuminuria.

itself, as this frequently connotes not a true or specific pregnancy toxaemia but an essential hypertension. The exclusion from the above groups of cases with hypertension as the sole clinical condition leaves those women in whom the diagnosis of toxaemia is based upon albuminuria, oedema, etc., with or without, but generally with, hypertension. This treatment of the figures may result in the exclusion of some cases in which the hypertensive state is due to toxaemia, but any such disadvantage is offset by the fact that, apart from any possible differential benefit derived from the supplementary diet in one group, each group is being similarly treated. It has the advantage of segregating for special study those cases in which the diagnosis of toxaemia rests on a reasonably secure foundation.

On this basis the primigravidae who received the additional dietary ingredients had an incidence of toxaemia of 5.4 per cent, while in the primigravidae who did

not receive any additional diet the percentage was 7.4. The difference and its standard error was 2 ± 0.9 , which means that the odds are nearly 40 to 1 against such a result being obtained by mere chance. The figures were also favourable to the parous women, but not to a significant degree, the percentages being 3.6 and 5.2 respectively, the difference being 1.6 ± 0.9 (see Table II). These results are striking, and indicate that the women receiving the special diet are protected against the risk of toxæmia in a ratio

London area, in which it is known that the incidence of toxæmia is low.

In a further classification based upon the criteria generally accepted for "pre-eclampsia"—namely, hypertension with albuminuria, oedema, et cetera—the following toxæmia rates were obtained: treated primigravidae, 4.51 per cent; untreated primigravidae, 6.42 per cent; the difference being 1.91 ± 0.82 ; treated multiparae, 3.16 per cent; untreated multiparae, 4.6 per cent; the difference being 1.44 ± 0.87 (see Table II).

TABLE II.
Pregnancy Toxæmia.

				Hypertension only		Albuminuria with or without hypertension		Hypertension with albuminuria, etc. (pre-eclampsia)	
No. of women				Cases	Per cent	Cases	Per cent	Cases	Per cent
<i>Primiparae:</i>									
Treated	...	...	1530	332	21.7	83	5.4	69	4.51
Controls	...	...	1512	368	24.3	112	7.4	97	6.42
Difference (C-T)				2.6±1.5		2.0±0.9		1.91±0.82	
<i>Multiparae:</i>									
Treated	...	...	980	179	18.3	35	3.6	31	3.16
Controls	...	...	999	166	16.6	52	5.2	46	4.60
Difference (C-T)				-1.7±1.7		1.6±0.9		1.44±0.87	
Total				1045		282		243	

which is almost 30 per cent. When it is remembered that, next to puerperal sepsis, toxæmia is the most important cause of the maternal death-rate (about 20 per cent of the total)* in addition to being one of the most fertile sources of chronic ill-health after childbirth, the findings of the committee assume a significance which it is hardly possible to over estimate. This investigation has been carried out in the

* Since the years when this investigation was carried out and owing chiefly to the fall in the death-rate from puerperal sepsis the comparative importance of toxæmia has increased. This condition is now responsible for just under 30 per cent of the total maternal mortality.

Differences According to Hospital.

There are marked differences in the incidence of albuminuric toxæmia in individual hospitals. Thus in Hospital B in 234 primiparae the rate was 2.1 per cent and in 232 multiparae 2.1 per cent. At the upper extreme Hospital F had a rate of 8.7 per cent in 287 primiparae and of 11.4 per cent in 228 multigravidae.

Toxæmia According to Original Standard.

Table III represents the data based upon this standard and it shows the vital importance of age and parity. The rates are seen to be correlated in a positive manner with each of these factors (see Table III).

Age and Parity.

Primiparae. It will be seen that for the "All Ages" group the percentage of toxæmia in the treated primiparae is significantly lower than in the controls, the respective figures being 27.1 per cent and 31.7 per cent, a difference of 4.6 ± 1.7 per cent. This result, however, is due to the dominating influence of the statistical experience of women aged 25 to 30, where the difference is 7.7 ± 2.6 per cent. At the younger and older ages the difference, although still favouring the treated groups, is statistically unimportant.

inverse relationship between the duration of the treatment and the morbidity-rate. The results are given in Table IV and they do not support this hypothesis. In point of fact they suggest the existence of a saturation level with 16 to 20 weeks treatment at which the best results are obtained. Here the treated primiparae are statistically superior to the controls—20.7 per cent as against 31.7 per cent. The multiparae are not quite so definite—18.6 per cent against 21.8 per cent. With prolongation of treatment beyond this interval the incidence increases and, for a duration of

TABLE III.
Pregnancy Toxæmia (Original Standard)
Distribution by Age and Parity.

Primiparae							
Age group	Treated			Controls			Difference (C-T)
	No. of observations	No. toxæmic	Per cent	No. of observations	No. toxæmic	Per cent	
Under 25	604	144	23.8	610	166	27.2	3.4 ± 2.5
25-29	633	166	26.2	623	211	33.9	7.7 ± 2.6
30 and over	293	105	35.8	279	102	36.6	0.8 ± 4.0
All ages	1530	415	27.1	1512	479	31.7	4.6 ± 1.7

Multiparae							
Age group	Treated			Controls			Difference (C-T)
	No. of observations	No. toxæmic	Per cent	No. of observations	No. toxæmic	Per cent	
Under 25	150	27	18.0	177	26	14.7	-3.3 ± 4.1
25-29	371	69	18.6	349	71	20.4	1.8 ± 2.9
30 and over	459	118	25.7	473	121	25.6	-0.1 ± 2.9
All ages	980	214	21.8	999	218	21.8	0.0 ± 1.9

Multiparae. In the "All Ages" group the treated incidence of 21.8 per cent which equalled that for the controls, and, in 2 out of 3 specific age groups, they were, if anything at a disadvantage.

Duration of Treatment.

If the treatment were effective in controlling incidence one might expect an

24 weeks or more, the experience of the treated is worse than that for the controls. It is possible that, since no allowance was made for age in the compilation of this table, some of the difference observed may be due to this cause, but, superficially, there seems no reason to suppose that there was any correlation between age and length of treatment (see Table IV).

*Differences in Incidence of Toxaemia
According to Hospital.*

A great range in the incidence of toxæmia, according to the above standards, was found to obtain in the different hospitals. Thus, in primiparae this incidence varied from 58.9 per cent in Hospital F to 5.6 per cent in Hospital B. The corresponding incidences in the multiparae were 40.3 and 6 per cent. In Table V the figures for the hospitals are shown. It is difficult to explain the extreme variations.

The results for the multiparae reveal no such correlation. There is no satisfactory evidence in favour of treatment. In regard to the primiparae the rates for the treated are 4.6 per cent and for the controls 4.2 per cent with an insignificant difference of -0.4 ± 0.7 in favour of the latter. The comparable values for the multiparae were 2.3 per cent and 2.2 per cent.

Seasonal Influence (Table VII). There is a well-defined seasonal trend in the prevalence of sepsis amongst primi-

TABLE IV.
*Pregnancy Toxaemia (Original Standard)
Distribution by Duration of Treatment.*

Length of treatment	Primiparae				Multiparae			
	No. of observations	No. toxaemic	Per cent	Difference (C-T)	No. of observations	No. toxaemic	Per cent	Difference (C-T)
Controls	1512	479	31.7		999	218	21.8	
Under								
16 weeks	288	72	25.0	6.7 ± 3.0	171	35	20.5	1.3 ± 3.4
16-	411	85	20.7	11.0 ± 2.5	279	52	18.6	3.2 ± 2.8
20-	414	114	27.5	4.2 ± 2.6	274	67	24.5	-2.7 ± 2.8
24 or more	417	144	34.5	-2.8 ± 2.6	256	60	23.4	1.6 ± 2.9

That they cannot be attributed to differences in ages in the different populations is clearly shown by a reference to column 1, which expresses under primiparae the percentage of women under age 25 and under multigravidae the percentage under age 30 (see Table V).

SEPSIS.

The results (Table VI) conform to the usual clinical experience that the incidence of sepsis is related to parity. The rate amongst the primiparae is approximately 4.5 per cent as compared with 2.2 per cent amongst the multiparae, an excess of about 100 per cent (see Table VI).

Influence of Age and Parity. It is seen that the incidence increases with age for primiparae, the rates being 3.3 per cent for age under 25, 5 per cent for age 25 to 30 and nearly 6 per cent for women over 30.

parae, the percentage during October-March being 5.3 as compared with 3.5 during April-September. On the other hand, it is only amongst the controls for multiparae that the seasonal factor is demonstrated, the respective winter and summer rates being 2.8 per cent and 1.5 per cent, but at no period of the year, either for primiparae or multiparae are the sepsis rates of the treated statistically better than those of the controls (see Table VII).

Influence of Duration of Treatment. (Table VIII). When the data were classified according to duration of treatment and the results compared with those for the controls, no apparent divergence was noted. The primiparae who had taken the vitamin diet for 24 weeks and more had a sepsis-rate of 4.8 per cent as against 4.2

per cent for the controls. The comparable figures for the multiparae were 2.2 per cent and 2.3 per cent in both instances, negligible differences. Furthermore the results reveal no negative relationship between the incidence and the length of time over which treatment was taken as the

DURATION OF LABOUR.

The data under this heading are shown in Table X, and it is seen that at "all ages" there is no significant difference between the treated and controls. In the individual age groups the only difference is in the primiparae class 30 and over, a difference

TABLE V.
Incidence of Toxaemia According to Hospitals.
(Original Standard)

Primiparae				
Percentage under age 25	Hospital	Total numbers	Toxaemia per cent	
			Albuminuria with or without hypertension	Hypertension
60-70	B	234	2.1	5.6
50-60	F	287	11.5	58.9
40-50	A	354	9.0	31.6
	E	55	10.9	58.2
30-40	C	505	9.7	27.8
	D	305	6.2	28.9
	G	263	4.9	24.3
	H	451	5.1	24.6
20-30	I	303	4.3	28.4
	J	286	5.2	27.6
Multiparae				
Percentage under age 30	Hospital	Total numbers	Toxaemia per cent	
			Albuminuria with or without hypertension	Hypertension
70-80	E	57	3.5	36.8
60-70	A	239	5.9	27.6
50-60	B	232	2.2	6.0
	C	253	5.1	18.6
	D	71	5.6	32.4
	H	148	1.4	20.2
	I	223	1.8	22.4
40-50	F	228	11.8	40.3
	G	218	2.3	18.3
	J	310	2.9	15.8

rates amongst women who had the diet for longer than 6 months are no better than those listed for a duration of less than 4 months (see Table VIII).

Distribution by Site. Table IX exhibits the various types of sepsis met with (see Table IX).

of 3.3 hours in favour of the treated which almost approaches significance. In the other age groups, both for primiparae and multiparae there is no significant difference between the treated and controls.

The table demonstrates in a very clear form the high positive correlation between

TABLE VI.
Sepsis.
Distribution by Age and Parity.

Primiparae.							
Age group	Treated			Controls			Difference (C-T)
	No. of observations	Sepsis	Per cent	No. of observations	Sepsis	Per cent	
Under 25	604	20	3.3	609	21	3.4	0.1 ± 1.0
25-29	631	34	5.4	623	28	4.5	-0.9 ± 1.2
30 and over	293	17	5.8	277	15	5.4	-0.4 ± 1.9
All ages	1528	71	4.6	1509	64	4.2	-0.4 ± 0.7

Multiparae							
Age group	Treated			Controls			Difference (C-T)
	No. of observations	Sepsis	Per cent	No. of observations	Sepsis	Per cent	
Under 25	150	4	2.7	177	2	1.1	-1.6 ± 1.5
25-29	371	10	2.7	349	11	3.2	0.5 ± 1.3
30 and over	458	9	2.0	470	9	1.9	-0.1 ± 0.9
All ages	979	23	2.3	996	22	2.2	-0.1 ± 0.7

TABLE VII.
Sepsis.
Distribution by Season of Confinement

Primiparae							
Period	Treated			Controls			Difference (C-T)
	No. of observations	Sepsis	Per cent	No. of observations	Sepsis	Per cent	
January-March	416	21	5.0	391	17	4.3	-0.7 ± 1.5
April-June	369	12	3.3	367	12	3.3	0.0 ± 1.3
July-September	334	13	3.9	384	14	3.6	-0.3 ± 1.4
October-December	409	25	6.1	357	21	5.7	-0.4 ± 1.7
All periods	1528	71	4.6	1509	64	4.2	-0.4 ± 0.7

Multiparae							
Period	Treated			Controls			Difference (C-T)
	No. of observations	Sepsis	Per cent	No. of observations	Sepsis	Per cent	
January-March	263	5	1.9	274	9	3.3	1.4 ± 1.4
April-June	206	2	1.0	223	5	2.2	1.2 ± 1.2
July-September	235	8	3.4	243	2	0.8	-2.6 ± 1.3
October-December	275	8	2.9	256	6	2.3	-0.6 ± 1.4
All periods	979	23	2.3	996	22	2.2	-0.1 ± 0.7

age and duration of labour known to exist in primiparae. The figures rise progressively from 18 hours in the age period 15 to 20 to about 26 hours at 30 and over. There is no age correlation in multiparae which throughout the various age groups

THE INFANT.

LENGTH OF GESTATION.

The length of pregnancies is analysed (Table XI) under 40 weeks, 40 weeks exactly, and over 40 weeks. It is seen that the two

TABLE VIII.
Sepsis.
Distribution by Duration of Treatment.

Primiparae				
Length of Treatment	No. of observations	Number of cases of sepsis	Per cent	Difference (control-treated)
Controls	1509	64	4.2	
Under 16 weeks	288	11	3.8	0.4 ± 1.3
16-	411	24	5.8	-1.6 ± 1.2
20-	412	16	3.9	0.3 ± 1.1
24 weeks and more	417	20	4.8	-0.6 ± 1.1
Multiparae				
Length of Treatment	No. of observations	Number of cases of sepsis	Per cent	Difference (control-treated)
Controls	996	22	2.2	
Under 16 weeks	171	4	2.3	-0.1 ± 1.2
16-	278	8	2.9	0.7 ± 1.0
20-	274	5	1.8	0.4 ± 1.0
24 weeks and more	256	6	2.3	-0.1 ± 1.0

TABLE IX.
Distribution by Site.

					Primiparae		Multiparae	
					Treated	Control	Treated	Control
1. General septicaemia	...	...	...	...	1			
2. Local pelvic sepsis	...	...	...	...	21	23	9	9
3. Mastitis	...	...	...	...	13	13	6	7
4. Urinary tract infection	...	...	...	...	28	18	6	5
5. Sepsis after Caesarean section	...	...	...	...	5	3	2	1
2 and 4	...	...	...	...	1	2		
3 and 4	...	...	...	...	1	1		
2 and 3	...	...	...	...		1		
4 and 5	...	...	...	...		2		
1 and 2 and 4	...	...	...	...		1		
Local sepsis	...	...	...	...	1			
All sepsis	...	...	...	...	71	64	23	22

varies little from a mean of about 12 hours; i.e., about half that for primiparae (see Table X).

distributions (Treated and Control) differ significantly. The value of X^2 was 11.186 with $P < 0.01$. This result means that the

probability of obtaining a similar distribution by chance is less than one in 100 trials. This result—the smaller incidence of prematurity among the treated women

so is a decreasing function of age (Table XII). Of the primiparous women aged under 25 years, 90 per cent breast feed their babies and for mothers aged 30 the propor-

TABLE X.
Duration of Labour in Hours.

Primiparae						
	15-19		20-24		25-29	
Age group	No. of observations	Mean and S.E.	No. of observations	Mean and S.E.	No. of observations	Mean and S.E.
Treated	90	17.5 ± 1.40	511	21.5 ± 0.81	619	23.2 ± 0.72
Controls	84	18.3 ± 1.25	523	20.5 ± 0.73	616	22.6 ± 0.73
Difference (C-T)	0.8 ± 1.9		-1.0 ± 1.1		-0.6 ± 1.0	
30 and over			All ages			
Age group	No. of observations	Mean and S.E.	No. of observations	Mean and S.E.		
Treated	283	27.3 ± 1.38	1503	23.1 ± 0.49		
Controls	272	24.0 ± 1.35	1495	21.9 ± 0.47		
Difference (C-T)	-3.3 ± 1.9		-1.2 ± 0.7			
Multiparae						
	Under 25		25-29		30-34	
Age group	No. of observations	Mean and S.E.	No. of observations	Mean and S.E.	No. of observations	Mean and S.E.
Treated	149	11.2 ± 0.78	366	12.2 ± 0.56	278	10.8 ± 0.59
Controls	177	11.1 ± 0.72	346	12.4 ± 0.65	281	12.5 ± 0.76
Difference (C-T)	-0.1 ± 1.1		0.2 ± 0.9		1.7 ± 1.0	
35 and over			All ages			
Age group	No. of observations	Mean and S.E.	No. of observations	Mean and S.E.		
Treated	173	11.9 ± 0.92	966	11.6 ± 0.34		
Controls	182	11.3 ± 0.72	986	12.0 ± 0.37		
Difference (C-T)	-0.62 ± 1.2		0.4 ± 0.5			

—is of special importance in view of the fact that about 50 per cent of infant deaths under one month are due to prematurity (see Tables X and XI).

BREAST FEEDING.

The ability of the mother to breast feed her baby, or, rather, the proportion who do

tion is 76 per cent. For the youngest primiparae the controls have a statistically better record than the treated, the respective rates being 91 per cent and 87.3 per cent, or a difference of 3.7 ± 1.8 , which is just outside the limits of random error due to sampling. For women of other ages the results are absolutely identical.

Amongst multiparae there is an inverse correlation with age as amongst the primiparae. If we take the age group 30 and over as one in which malnutrition is most

children as compared with 85.3 per cent of the latter, a difference of 4.1 ± 2.2 , which approaches the level of significance.

The influence of duration of treatment

TABLE XI.
Period of Gestation and Length of Treatment.

	Primiparae				Multiparae			
	Treated		Controls		Treated		Controls	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Under 40 weeks	308	20.1	362	23.9	197	20.1	241	24.2
40 weeks exactly	1060	69.3	990	65.5	674	68.8	654	65.7
More than 40 weeks	161	10.5	160	10.6	109	11.1	101	10.1
Not stated	1		1				3	
Total	1529	100	1512	100	980	100	996	100
	1530		1513		980		999	

TABLE XII.
Breast feeding.
Distribution by Age of Mother and Parity.

	Primiparae						
	Treated			Controls			Difference
	No. of live births	No. breast fed	Per cent	No. of live births	No. breast fed	Per cent	(controls-treated)
Under 25	588	513	87.3	590	537	91.0	3.7 ± 1.8
25-29	615	515	83.7	606	507	83.7	0 ± 2.1
30 and over	284	218	76.8	267	205	76.8	0 ± 3.6
All ages	1487	1246	83.8	1463	1249	85.4	1.6 ± 1.3

	Multiparae						
	Treated			Controls			Difference
	No. of live births	No. breast fed	Per cent	No. of live births	No. breast fed	Per cent	(controls-treated)
Under 25	147	133	90.5	176	151	85.8	-4.7 ± 3.7
25-29	367	332	90.5	342	311	90.9	0.4 ± 2.2
30 and over	442	377	85.3	454	406	89.4	4.1 ± 2.2
All ages	956	842	88.1	972	868	89.3	1.2 ± 1.4

likely to occur because of the existence of a larger household we find that the controls have a better record than the treated; 89.4 per cent of the former breast fed their

was studied. It was found that, although the percentage of children breast fed increased with extended treatment, it is only when the mothers had taken the supple-

mentary diet for 24 weeks and over that their ability to breast feed was slightly better than that of the controls. The respective values were 87.4 per cent as against 85.4 per cent, with a difference of -2 ± 2 which is within the range of a chance variation.

There is a wide range in the percentage of breast feeding in individual hospitals. Thus, whilst in hospital G the rate is 68.8

INFANT MORTALITY.

It might be expected that, as the babies of the treated mothers had the more favourable experience in regard to prematurity and birth weight, they would show lower rates in respect of stillbirth and neonatal mortality. In regard to stillbirth this was found to be the case as is shown by the following table (see Table XIII).

TABLE XIII.
Infant Mortality.

Primiparae				Treated	Per cent	Controls	Per cent
Stillbirths	...	...	...	37	2.4	47	3.1
Died before 8 days	...	...	...	20	1.3	12	0.8
Total	...	...	...	57	3.7	59	3.9

Multiparae				Treated	Per cent	Controls	Per cent
Stillbirths	...	...	...	20	2.0	22	2.2
Died before 8 days	...	...	...	14	1.4	12	1.2
Total	...	...	...	34	3.4	34	3.4

per cent, in hospitals B and J the rates are 92.9 and 94.3 per cent respectively. The values in the multiparae class are, on the average, higher than those in the primiparae. These results suggest that the incidence of breast feeding is to a large extent determined by such factors as hospital practice and discipline and that it does not necessarily reflect the physiological ability of the mother to feed her baby.

It is shown, however, that this advantage does not apply in regard to neonatal mortality which is appreciably higher in babies born to treated primiparae and slightly higher in treated multiparae.

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Sensitization of the Vascular System in Pre-eclamptic Toxaemia and Eclampsia

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HYPERTENSION is one of the earliest and most constant signs of pre-eclamptic toxaemia, yet its cause remains undetermined. The investigations of Kellar and Sutherland¹ have shown that it is due not to a nervous mechanism but to a humoral substance. It is not known what this humoral substance is, but it has been demonstrated that it is not renin, hypertensin,² adrenalin or tyramin.³ Hoffman, Anselmino and Kennedy⁴ claimed that in pre-eclamptic toxaemia and eclampsia there was in the patient's circulation excess of a pressor substance derived from the posterior pituitary gland. This pressor principle was demonstrable in excess in ultra-filtrates of the plasma of all pre-eclamptic or eclamptic patients whose blood-pressure exceeded 180 mm. Hg. Other workers, however, failed to confirm these claims.^{5, 6, 7, 8, 9, 10} Byrom,^{11, 12} discussing the question as to whether excess of a pressor substance can be the cause of the hypertension, says that the amount of vasopressin required to produce it would be so large that "it is difficult to believe that eclampsia can be due wholly to over secretion of this hormone. The question therefore arises whether some dislocation of equilibrium arising out of pregnancy may not render the vessels over sensitive to this hormone." Bourne and Burn¹³ had found that the response of uterine muscle to oxytocin could be greatly enhanced by oestrin (oestradiol benzoate). This suggested to Byrom the study of the effect of sex hor-

mones on the response of the rat to vasopressin. By injecting measured amounts of vasopressin he produced lesions closely resembling those of eclampsia, including a rise of blood-pressure of 50 mm. Hg. or more, anaemic infarcts in the kidneys symmetrically distributed throughout the deeper layers of the cortex, focal necrosis in the liver, albuminuria, coma and death. He believed the visceral lesions to be due to arteriolar spasm. He also found that the sensitivity of the rat could be so increased by preliminary treatment with oestrogens, that the same effect could be produced by one tenth of the original dose of vasopressin, and that in unsprayed rats the sensitization could equally well be caused by gonadotropic hormone (aqueous solution of extract of pregnancy urine). The sensitization was not prevented or modified by simultaneous injection of progesterone. Byrom concluded that gonadotropic hormone, though predominantly luteinizing in action, caused sensitization by stimulating ovarian secretion of oestrin and that oestrin-sensitization is in some way concerned in the genesis of eclampsia.

Shockart and Lambillon¹⁴ using tonephin, and simultaneously and independently Dieckmann and Michel¹⁵ using pituitrin, showed that nulliparous women, normal pregnant women and women suffering from pre-eclamptic toxaemia reacted differently to injected pressor substances. This work was confirmed in its essentials by de Valera and Kellar¹⁶ and Browne.¹⁷ The

results of these different workers are shown in the following table (Table I).

It will be seen that while the results differ in certain details all agree that in pre-eclamptic toxæmia there is, as compared with normal pregnancy at or near term, a very severe reaction indicated by a large rise of systolic pressure after injection of a standard amount of the pressor substance. This difference in reaction must be due to a

from the first day of the last menstrual period. The results are shown in Table II. In carrying out these tests the base level of the blood-pressure is first obtained by making successive blood-pressure estimations with the patient at rest, lying down. This generally entails 7 or 8 tests spread over half an hour or more. The lowest systolic reading and the lowest diastolic reading are taken as the "base level."

TABLE I.
*Reactions to Pressor Substances (Rise of Systolic Arterial Pressure in mm. Hg.
in Normal and Toxaemic Women).*
(Comparative Results of Various Workers.)

	Shockaert and Lambillon (Tonephin)	Dieckmann and Michel (Pituitrin)	de Valera and Keller (Tonephin)	Browne (Tonephin)
Normal women not pregnant	45	—	35	21.3
Normal pregnant women	13	11	23	33.2
Pre-eclamptic toxæmia	55	51	43	54
Pregnancy with chronic hypertension	16	7.7	—	53
Normal puerperal	44	—	44	48.2

difference in sensitivity of the vascular system in the one as compared with the other.

THE PRESENT INVESTIGATION.

Two questions now arise: (1) Is this abnormal sensitivity constitutional or is it acquired in the course of the development of the pre-eclamptic toxæmia? (2) If it is acquired what causes it?

It seemed that the first question could be answered by testing the reactions to pressor substances in a series of normal women in the early weeks of pregnancy and comparing the results with those obtained in any patients of the group who later developed pre-eclamptic toxæmia. This was done in 27 women at their first attendance at the antenatal clinic. The duration of the pregnancy at this time varied from 8 to 20 weeks and the average was 13 weeks counting

Tonephin 0.66 c.cm. is then injected into an arm, care being taken to inject slowly and to deflate the cuff as soon as the needle has entered the vein. Systolic readings are then taken as rapidly and in as quick succession as possible for 2 or more minutes. The difference between the systolic basic pressure and the highest systolic reading after injection is a measure of the reaction to the tonephin. Diastolic readings may also be made but in the writer's experience they are liable to be inaccurate, and in attempting to note them so much time is wasted that the highest level reached by the systolic pressure is apt to be missed. This only refers to estimations of the diastolic pressure after injection of tonephin. In obtaining the basic level before tonephin is injected it is easy to obtain the diastolic pressure. Those given in Table II are the points at which the sound disappeared.

TABLE 11.
Reactions to Pressor Substance in Early Normal Pregnancy.

Identification number	Weeks pregnant	Base level of blood-pressure (mm. Hg.)		Systolic blood-pressure after tonephrin (mm. Hg.)	Difference in systolic pressure (mm. Hg.)	Signs of toxæmia in late pregnancy if blood-pressure over 120/80
		Systolic	Diastolic			
1	13	118	70	148	30	135/80
2	20	112	46	130	18	None
3	11	114	55	142	28	132/82
4	11	140	65	180	40	134/80
5	20	118	58	144	26	141/80
6	13	115	50	135	20	None
7	17	134	55	150	16	150/95
8	10	110	50	145	35	124/84
9	13	118	60	132	14	None
10	11	118	40	140	22	150/100
11	10	102	50	126	24	None
12	14	120	45	146	26	130/86
13	20	116	55	130	14	None
14	11	120	50	125	5	150/100
15	16	110	50	124	14	122/80
16	13	100	50	105	5	None
17	14	120	50	140	20	None
18	11	110	60	130	20	None
19	10	106	40	128	22	Evacuated
20	9	90	40	92	2	Evacuated
21	10	108	50	150	42	I U death at 20 weeks
22	8	102	45	130	28	Evacuated
23	16	100	45	130	30	Evacuated
24	10	112	18	140	28	Evacuated
25	17	98	45	125	27	Illegitimate pregnancy. Miscarriage after 21 weeks
26	12	126	55	130	4	Evacuated
27	12	110	40	120	10	Evacuated

It was expected that some of these 27 women would develop pre-eclamptic toxæmia. The reaction to tonephrin of any who did so could then again be tested. If it were found to be significantly raised it would show that the sensitization which must necessarily account for the heightened reaction was acquired in the course of the pregnancy in the period between the first and second tests. It was decided to adopt for the purpose of this investigation a blood-pressure of 140/90 or over with or without oedema and albuminuria as the standard of pre-eclamptic toxæmia. Seven of the

women were evacuated to the country during the air attacks on London and in 2 others the pregnancy ended prematurely. Three of the remaining women actually reached the standard mentioned, viz., Numbers 7, 10 and 14 in Table II. In Number 14 difficulty was met with in entering the vein at the second test which had in consequence to be abandoned. The essential details regarding the remaining 2, are as follows:

NUMBER 7. Primigravida, aged 21, L.M.P. January 7th to 12th, 1944. First attendance on May 8th, that is, 17th week of pregnancy.

Apparently healthy; urine normal; blood-pressure 140/62; base level 100/40. After injection of tonephin systolic pressure rose to 150 mm. Hg. Reaction 16 mm. Hg. On September 11th, 1944, her blood-pressure was 150/95. Slight swelling of ankles but no albuminuria; on September 18th blood-pressure was 132/82. No albumin or oedema, and on September 25th the second tonephin test was done. Blood-pressure (ordinary reading at rest) 150/80. Base level 100/40; after tonephin systolic pressure rose to 170. Reaction 70 mm. Hg. as compared with 16 mm. Hg. at the first test.

NUMBER 10. Primigravida, aged 36, L.M.P. November 21st to 25th, 1943. First attended clinic on February 3rd, 1944, that is at the 11th week of pregnancy. Healthy woman, urine normal, blood-pressure 124/50. Base level of blood-pressure 118/40. After injection of tonephin systolic blood-pressure rose to 140 mm. Hg. The reaction to tonephin was therefore 22 mm. Hg. On July 20th her blood-pressure was 150/92 and a week later 150/100. There was some oedema of the ankles but no albuminuria. She was admitted to hospital on August 1st, 1944, and the second tonephin test was done next day. The basic level of blood-pressure was estimated as 132/70 and after tonephin the systolic pressure rose to 190. The reaction was therefore 58 systolic compared with 22 systolic at the first test.

These two cases show that the patient who develops pre-eclamptic toxæmia acquires an abnormal sensitivity of the vascular system to the action of pressor substances and that this develops between the early weeks of pregnancy (? 17th week) and the time of appearance of the pre-eclamptic toxæmia.

Attempts were now made to find an answer to the second question, i.e., What causes the sensitization?

Shockaert and Lambillon¹⁴ and de Valera and Kellar¹⁶ found that normal pregnant women gave a lower reaction to tonephin than normal women who were not pregnant; they concluded that there must be in normal pregnancy some inhibiting substance and that the absence of this

substance might be the cause of the high reaction found in pre-eclamptic toxæmia. The present writer¹⁷ found that the contrary was the case (see Table I) and that there was not any evidence of the presence of an inhibiting substance.

Certain considerations suggested that chorionic gonadotropin might be the substance responsible for the sensitization. Smith and Smith¹⁸ have reported the presence of abnormally high levels of the anterior pituitary like hormone in the serum and urine of patients with late pregnancy toxæmia and eclampsia and that this increase can be demonstrated 5 or 6 weeks before other signs and symptoms of toxæmia appear. Then there is the fact that in hydatidiform mole in which the output of chorionic gonadotropin is much increased the incidence of pre-eclamptic toxæmia is higher than in normal pregnancy, while some 20 cases of eclampsia have been recorded, though hydatidiform mole usually occurs within the first 3 months of pregnancy. It was therefore decided to try this substance in the first instance and to use synapoidin (Parke, Davis & Co.), a synergistic preparation containing anterior pituitary extract in combination with urinary chorionic gonadotropin. This was preferred to simple chorionic gonadotropin as it would obviously be difficult to inject sufficient of the latter to produce any clinical effect. Several women who were being treated expectantly in the hospital on account of mild antepartum haemorrhage were given daily injections of synapoidin, tonephin tests being done before and after the course of injections in order to test the change in sensitivity, if any. Only women were treated who were likely to be in the hospital for at least 2 or 3 weeks, whose blood-pressure readings had never exceeded 120/80 mm. Hg., whose urine was normal, and who were apart from the mild antepartum haemorrhage apparently

healthy in every respect. In some cases oestrogenic substance (Theelin P. D. & Co.) was used instead of synapoidin but these are few in number and it is doubtful whether enough of the preparation was injected. In one case eucortin was used and the completely negative result obtained is of great interest.

The essential details of the patients treated, the nature and amount of the materials used and the results, as regards sensitization, are as follows:

CASE 1. Mrs. J.E., primigravida, aged 29. Admitted March 3rd, 1945, for slight antepartum haemorrhage at 34th week of pregnancy; no evidence of toxæmia; no extra placental causes of haemorrhage found; no further haemorrhage. Spontaneous delivery at term; mother and child well. Final diagnosis and classification: antepartum haemorrhage of uncertain origin.

17.3.1945. First tonephin test. Base level of blood-pressure 100/44; reaction after tonephin 20 mm. Hg. systolic. Patient then given synapoidin, 1 c.cm. daily for 10 successive days.

26.3.1945. Second tonephin test. Base level of blood-pressure 104/58. Reaction after tonephin 34 mm. Hg. systolic. Patient then had 2 c.c. synapoidin daily for 5 days ending March 30th, 1945.

31.3.1945. Third tonephin test. Base level of blood-pressure 104/46. Reaction after tonephin 40 mm. Hg. Synapoidin continued daily for 6 more days ending April 6th, 1945.

7.4.1945. Fourth tonephin test. Base level of blood-pressure 102/50. Reaction after tonephin 53 mm. Hg.

Delivered April 19th, 1945. There was not, at any time, before or during the treatment evidence of pre-eclamptic toxæmia and the highest recorded blood-pressure was 124/70.

Comment. This patient appears to have been sensitized by injection of synapoidin. There was a gradual and consistent rise in the reaction to injection of tonephin from 20 mm. Hg. systolic to 53 mm. Hg.

CASE 2. Mrs. M. P.; primigravida, aged 21. Admitted on April 19th, 1945, for slight antepartum haemorrhage at 31 weeks. No evidence of toxæmia; no extraplacental cause for antepartum

haemorrhage found. Treated expectantly. No further haemorrhage. Delivered spontaneously at term. Mother and child well. Final diagnosis and classification antepartum haemorrhage of uncertain origin.

27.4.1945. First tonephin test. Base level of blood-pressure 109/55. Reaction after tonephin 29 mm. Hg. systolic. Patient then given 2 c.cm. synapoidin daily till April 17th, 1945 (42 c.cm.).

18.5.1945. Second tonephin test. Base level of blood-pressure 109/60. Reaction after tonephin 23 mm. Hg. systolic. Synapoidin continued, 2 c.cm. being given daily up to and including May 30th, 1945 (24 c.cm.).

31.5.1945. Third tonephin test. Base level of blood-pressure 110/65. Reaction after tonephin 55 mm. Hg. systolic.

Delivered June 24th, 1945. The highest blood-pressure after synapoidin injection was 130/85 on June 9th, by which time she had received 80 c.cm. According to our standard of normal blood-pressure (120/80) this was raised. It remained about this level till delivery when it fell to 118/90.

Comment. This patient seems to have been sensitized by the synapoidin as the reaction to tonephin increased from 29 mm. Hg. systolic to 53. The failure to become sensitized by the time of the second test is hard to explain. It should be recalled, however, that Smith and Smith found that the excess of anterior pituitary-like hormone was present for 5 or 6 weeks before the onset of toxæmia.

CASE 3. Mrs. B. G., aged 25, one previous child. Admitted October 5th, 1945, for slight antepartum haemorrhage at 34 weeks. Extraplacental cause of haemorrhage was not found. There had been no evidence of toxæmia and the first pregnancy had been normal. Treated expectantly in hospital till spontaneous delivery at term on December 14th, 1945. Mother and child well. Final diagnosis and classification—antepartum haemorrhage of uncertain origin.

11.10.1945. First tonephin test. Base level of blood-pressure, 95/38. Reaction after tonephin 40 mm. Hg. systolic. Patient was then given 2 c.cm. synapoidin daily for 11 days up to and including October 21st, 1945.

25.10.1945. Second tonephin test. Base level of blood-pressure, 75/35. Reaction after tonephin 71 mm. Hg. systolic. No further injections given.

Comment. The rise in the reaction to tonephin seems to show that this patient was sensitized by synapoidin. The delay of 4 days in carrying out the second tonephin test may have resulted in the recorded sensitization being less than it otherwise would have been.

CASE 4. A. C., aged 34, 2 previous stillbirths due to difficult labour. Contracted pelvis, C.V., 3.6 inches. Admitted on February 28th, 1946, at 38 weeks for slight antepartum haemorrhage. No extraplacental cause for antepartum haemorrhage found. No previous toxæmia; treated expectantly. Caesarean section at term March 22nd, 1946. Mother and child well. Placenta found to be entirely in upper uterine segment.

March 5th 1946. First tonephin test. Base level of blood-pressure, 128/60. Reaction after tonephin, 16 mm. Hg. systolic. Patient then given 12 daily doses of 2 c.cm. synapoidin from March 7th, to March 18th, 1946, inclusive.

21.3.1946. Second tonephin test. Base level of blood-pressure 118/60. Reaction after tonephin 40 mm. Hg.

22.3.1946. Caesarean section. At the operation it was noted that both ovaries appeared to be normal and did not show any evidence of cystic change.

Comment. It is doubtful whether any sensitization was produced in this case. It will be noted that the base level of blood-pressure at the second test is 10 mm. Hg.; lower than at the first. If the reaction at the second test is counted from the original base level (128) the reaction at this test would only have been 30 mm. Hg. as compared with 16 mm. Hg. at the first. The absence of any visible cystic change in the ovaries is remarkable as it is well known that synapoidin usually causes cystic enlargement of the Graafian follicles. If, therefore, there was sensitization in this case it cannot be explained by stimulation of the follicles to produce excess of oestrogenic hormone.

Byrom,¹¹ however, though he presumed that the gonadotropic hormone with which he produced vascular sensitization in rats acted by stimulating the ovaries to produce oestrin, did not describe any cystic or other morbid change in the rats' ovaries.

CASE 5. B. T., aged 37, para 3. Admitted January 17th, 1946, for antepartum haemorrhage (about 3 ounces) at 34 weeks. No toxæmia (blood-pressure never above 120/80) in this pregnancy. Previous pregnancies said to be normal. Treated expectantly. Delivered spontaneously of a full-time child on March 9th, 1946. Final diagnosis and classification—antepartum haemorrhage of uncertain origin.

24.1.1946. First tonephin test. Base level 108/60. Reaction 22/20. Patient was then given synapoidin daily from January 29th to February 12th, 1946, i.e., 26 c.cm.

12.2.1946. Second tonephin test. Base level 110/60. Reaction after tonephin 24 mm. Hg. systolic. No further treatment was given.

Comment. Sensitization does not seem to have been caused in this case.

CASE 6. K.S., aged 35, not pregnant. Admitted December 6th, 1945, for investigation and treatment of secondary amenorrhoea which had been present, except for very occasional bleeding from vagina lasting one day, since the first and only pregnancy 3½ years before. Before that pregnancy the periods had lasted 3 days.

The pregnancy and labour had been uncomplicated and there had been no postpartum haemorrhage. Investigations of pituitary fossa and lungs failed to reveal any abnormality. B.M.R. + 14. Lipiodol outline of uterus and appendages showed left Fallopian tube patent, but uterus small. Biopsy of endometrium showed an atrophied mucous membrane with very few glands. Except for the absence of periods there was not any evidence of the presence of Simmond's disease and the patient looked and felt well.

7.12.1945. First tonephin test. Base level of blood-pressure 100/48. Reaction after tonephin 15 mm. Hg. systolic. Patient was then given 14 daily doses of synapoidin 2 c.cm. each, starting on December 15th, 1945.

28.12.1945. Second tonephin test. Base level

of blood-pressure 102/45. Reaction after tonephin 18 mm. Hg., systolic. Synapoidin was continued—2 c.cm. daily for 10 days together with stilboestrol Mg. X daily.

9.1.1946. Third tonephin test. Base level of blood-pressure 102/48. Reaction after tonephin 23 mm. Hg. systolic. Stilboestrol Mg. X and progesterone, Mg. V, were then given daily for 7 days.

17.1.1946. Fourth tonephin test. Base level of blood-pressure, 102/55. Reaction after tonephin, 30 mm. Hg. systolic. No further treatment. Discharged on January 19th, 1946.

Comment. There does not seem to have been any sensitization in this case. At no time during treatment did the ovaries become palpably enlarged. No period had occurred when discharged from hospital but on June 5th, 1946, she wrote to say that she had 3 scanty periods at irregular intervals, each lasting from 24 to 72 hours. Perhaps sensitization should not have been expected as the ovaries were probably atrophic. It will be recalled that Byrom concluded that gonadotropic hormone caused sensitization by stimulating ovarian secretion of oestrin.

CASE 7. W. F., age 41. Not pregnant, married 17 years, one induced abortion 10 years ago. Now complains of sterility. Periods regular. Puberty at 11; type, 6/31. Last menstrual period ended March 1st, 1946. No abnormality found in pelvis or elsewhere. Blood-pressure 115/80. Urine normal. Suction curettage on first day of period showed a normal secretory endometrium.

4.3.1946. First tonephin test. Base level of blood-pressure 115/70. Reaction after tonephin 35 mm. Hg. systolic. Patient was then given 1 c.cm. of synapoidin daily from March 25th to 30th inclusive.

1.4.1946. Second tonephin test. Base level of blood-pressure 108/75. Reaction after tonephin 42 mm. Hg. systolic. It is doubtful whether any sensitization occurred in this case.

CASE 8. E. E., aged 29. Sterility. Married 9 years; periods 5-9/2-6 weeks. Last menstrual period May 1st, 1946.

28.6.1946. First tonephin test. Base level of

blood-pressure, 100/56. Reaction after tonephin 30 mm. Hg. systolic. One c.cm. synapoidin daily from June 1st to 6th, 1946, inclusive.

7.6.46. Second tonephin test. Base, 116/60. Reaction after tonephin, 12 mm. Hg. systolic.

Comment. There was therefore no sensitization in this case. Probably far too little synapoidin was given and for too short a time.

CASE 9. M. C., primigravida, aged 22. Admitted on March 3rd, 1946, at 35 weeks because of slight antepartum haemorrhage. Cervix healthy. No toxæmia. Expectant treatment. Spontaneous delivery at term on April 15th, 1946. Mother and child well. Final diagnosis and classification—antepartum haemorrhage of uncertain origin.

26.3.1946. First tonephin test. Base level of blood-pressure, 108/30. Reaction after tonephin, 42 mm. Hg. systolic. Patient was then given theelin (Parke, Davis & Co.) 1 c.cm. daily from March 29th to April 9th, 1946, inclusive (1 c.cm. = 30,000 international units = 2 mg).

11.4.1946. Second tonephin test. Base level of blood-pressure, 105/45. Reaction after tonephin 60 mm. Hg. systolic.

CASE 10. R. V., age 30. Two previous children. Admitted May 22nd, 1946, at 32 weeks on account of slight antepartum haemorrhage. No toxæmia in this or last pregnancy. First pregnancy said to have been normal. No extraplacental cause of bleeding found.

30.5.1946. First tonephin test. Base level, 100/56. Reaction after tonephin, 25 mm. Hg. systolic. The patient was then given theelin, 1 c.cm. daily from May 31st to June 11th, 1946, inclusive.

12.6.1946. Second tonephin test. Base level of blood-pressure, 102/50. Reaction after tonephin, 32 mm. Hg. systolic.

Eucortin (Allen and Hanbury, a natural extract of adrenal cortex) was then injected, 1 c.cm. daily for 7 days from June 13th, to 19th, 1946. This did not cause any rise of blood-pressure or any visible oedema.

20.6.1946. Third tonephin test. Base level of blood-pressure, 90/46. Reaction after tonephin, 30 mm. Hg. systolic. One c.c. of theelin was again injected daily for 12 days from June 22nd to July 3rd, 1946.

4.7.1946. Fourth tonephin test. Base level, 96/50. Reaction after tonephin, 30 mm. Hg. systolic. There was therefore no demonstrable sensitization caused by the theelin or by the eucortin.

Comment. The absence of any rise of blood-pressure or oedema after injection of eucortin is interesting in view of the case reported by Altschule and Zamchek¹⁹ in which a man developed high blood-pressure and gross oedema and anasarca after

30 out of 32 experiments. Calculated on this basis the amount required for a human female would be about 300 mg. Actually Mrs. M. C. and Mrs. R. V. received only 24 and 48 mg. respectively.

DISCUSSION.

Examination of the case details and of the summary in Table III will show that the most striking results are obtained by the use of synapoidin and that even with that

TABLE III.
Summary of Results Obtained in Attempts to Sensitize the Vascular System by Various Substances.

Reference number	Pregnant or not	Substance used	Highest systolic reaction to tonephin before use of sensitizing substance	Highest systolic reaction to tonephin after use of sensitizing Substance
1	Pregnant	Synapoidin	20	53
2	Pregnant	Synapoidin	29	55
3	Pregnant	Synapoidin	40	71
4	Pregnant	Synapoidin	16	40
5	Pregnant	Synapoidin	22	24
6	Not pregnant	Synapoidin	15	23
		Stilboestrol		
		Progesterone		
7	Not pregnant	Synapoidin	35	42
8	Not pregnant	Synapoidin	30	12
9	Pregnant	Theelin	42	60
10	Pregnant	Theelin	25	30
		Eucortin		

administration of 5 grammes of common salt daily and 1 c.cm. cortin (Organon, a natural extract of adrenal cortex) daily for 1 week. Mrs. R. V., however, was only receiving the ordinary hospital diet with free use of salt at meals, about 15 grammes daily. The failure of theelin (an oestrogenic substance) to sensitize the patient is disappointing in view of the result of Byrom's experiments on rats already quoted. He states that the minimum effective dose in causing sensitization in the infant rat was about 0.01 to 0.02 mg. daily of an oily solution of oestrone for 5 or more days, with which dose he was successful in

the results are not always consistent. It is doubtful whether oestrogenic substances caused any sensitization though, as we have already seen, Byrom considered oestrin to be the substance responsible for the sensitization that he produced in rats, and that though it could also be produced by injection of gonadotropic hormone this only acted by stimulating the ovary to produce oestrin. He did not, however, describe any cystic change in the ovaries and presumably they were normal.

The work of Smith and Smith¹³ suggests that whatever the sensitizing substance be it is not oestrin, for in pre-eclamptic toxæmia

they found it diminished. Gonadotropic hormone, on the other hand, they found to be increased and this increase they were able to demonstrate as much as 5 or 6 weeks before the appearance of other signs of toxæmia. By the administration of oestrogenic substances too they claim to be able to diminish the quantity of gonadotropic hormone and thus prevent toxæmia. If, as Smith and Smith claim, gonadotropic hormone is increased for from 5 to 6 weeks before the appearance of toxæmia it would suggest the use of synapoidin for a longer period than in any of the experiments cited in the text. Meanwhile, so far as conclusions can be drawn from the present investigation, it seems to indicate that chorionic gonadotropic and not oestrogenic hormone is the sensitizing substance. It is probable, however, that neither substance was injected in sufficient quantities.

SUMMARY.

1. Evidence is brought forward that the cause of the hypertension in pre-eclamptic toxæmia is an abnormally increased sensitivity of the vascular system to pressor hormones rather than the presence in excess of the pressor hormone itself.

2. It is proved that this abnormal sensitivity is not inherent or constitutional but that it is acquired at some time between the 17th week and the onset of the clinical signs and symptoms of toxæmia.

3. Clinical considerations and the results of the clinical experiments cited in the text suggest that the sensitizing substance is chorionic gonadotropin rather than oestrogenic hormone or hormone of the adrenal cortex.

I am indebted to Messrs. Parke, Davis & Co. for the supply without charge of the

synapoidin and theelin used in the experiment, and to their medical adviser, Dr. Stanley White, for his interest and co-operation.

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The Superiority of the South African Negro or Bantu as a Parturient

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PART III.—A COMPARISON OF BANTU AND EUROPEAN PARTURITION IN TWO SERIES DERIVED FROM THEIR RESPECTIVE ANTENATAL CLINICS.

INTRODUCTION.

It is difficult to judge a parturient fairly when, as is the case in cities, the obstetrician's experience is derived from a hospital practice. The hospital is almost invariably the scene at which trained observers in this country can study labour in the South African Negro or Bantu. An opportunity of making observations in domiciliary midwifery on Bantu parturients has been offered. Seven years ago an antenatal clinic was started in a large native township, and it is now possible to assess labour as it occurred among the Bantu women who attended the clinic.

During the course of the work done, a strong impression was gained that the Bantu parturient was far more efficient than the European, and that she appeared to be much better adapted to the strain of labour, requiring instrumental or other operative delivery infrequently. This was the more surprising, because our studies have shown the Bantu head at birth to be as large as that of the European, and the Bantu pelvis to be slightly smaller. Moreover, there is in the Bantu a range of small pelves which is much lower than that of the non-pathological European girdle, and the incidence of these small pelves is relatively high.

A comparison of the labours recorded concerning patients from our European antenatal clinic and those from the Bantu clinic has been made for the quinquennial period 1940-1944, in order to arrive at an assessment of the 2 series of women relative to their success in parturition.

MATERIAL AND METHODS.

Material.

A comparison between Bantu and European labours has been made on the basis of material dealt with at the antenatal clinic. The analysis includes all cases seen over a period of 5 years (1940-1944) at:

1. The Municipal antenatal clinic for European Women in Johannesburg. While 5,059 patients are included in this survey, this does not represent the total number seen at the clinic during 1940-1944. Owing to a delay of 1 year after most of the antenatal cards had been studied, a difficulty arose which made it impossible to be precise about the inclusion of approximately half of the 1940 cards. These were, therefore, omitted, and those of the last quarter of 1944.

2. Alexandra Township. There were 1,433 women attending the local antenatal clinic during 1940-1944. The township is situated on the outskirts of Johannesburg and has a population of about 80,000. The men and some women are occupied in the city or its suburbs, but not on the gold mines; and there are numerous schools and churches in the township which is owned

by the inhabitants. There is a well-established polyclinic from which *inter alia* a district service is operated. Students are in residence here and attend the clinic, there are several doctors on the permanent staff, and the full-time personnel of the University Department of Obstetrics and Gynaecology conduct the antenatal clinics. Midwives consult the obstetricians concerning cases of abnormal labour, and these are transferred to the Bridgman Memorial Hospital (Maternity) when necessary. No instrumental or other complicated deliveries are effected on the district.

The women of the township are under European influences and their mode of life is similar to that of any urbanized European community. In spite of this, they are still Bantu, essentially primitive, and their instincts are still those of the women living under tribal conditions. Recently an increasing number of "raw" newcomers to the city has been attending—individuals who, in no obvious manner, conform to European standards and who were certainly reared in Native territories. Concerning the others, the less primitive women, it is not known whether they were born here or in their ancestral countries. It must be pointed out that Johannesburg began as a mining camp only 59 years ago.

The European Series.

There were 5,059 patients who attended the clinic. Of these 3,802, or 75.2 per cent, were delivered at the Queen Victoria Hospital. The remainder had their babies at home under the care of the Municipal District Service, and in the event of any abnormality developing during labour would have been sent to hospital. Of the 3,802 hospital women 1,564 or 41.2 per cent were primigravidae. If 1,564 primigravidae be taken against 5,059, the total for the series, the percentage of primigravidae seen was 30.93. The true figure is

slightly higher than this, because a small number of primigravidae was delivered on district. These were normal cases and cannot affect the analysis, as will be shown later.

The Bantu Series.

1,433 patients attended the clinic during the 5 years under consideration. Of these, 5 women aborted, and the records of 3 could not be traced. Of 1,425 patients who had viable babies 364, or 25.58 per cent, were primigravidae.

Methods.

The method of analysis followed the principles of statistics, and comparison between European and Bantu incidence was based on statistical significance. No apology will be offered for illustrating how it is decided whether a difference between percentage values for the two racial groups is "significant" or whether it may have arisen by chance. Therapeutic trial is often based on about 15 cases receiving therapy, and 15 controls. If the control group shows a few more successes than the therapy group, it has been thought that the therapeutic measures have been shown to lack value. This conclusion is not necessarily correct for, on the play of chance, certain differences must be expected. These chance differences become more unexpected as the groups observed become smaller.

In comparing 2 percentages, the standard error of each must be considered.

This is given by the factor $\sqrt{\frac{p \times q}{n}}$, where

p might be the percentage of European women requiring operative delivery and q the percentage not requiring operative delivery, n being the number in the sample. The standard error of the difference between European and Bantu percentages may be shown to be $\sqrt{\frac{p_1 \times q_1}{n_1} + \frac{p_2 \times q_2}{n_2}}$

where n_1 and n_2 are the numbers in the two samples, and p and q as above. If all circumstances were equal, it would be reasonable to expect the difference between European and Bantu percentages to be 0; but we might quite easily, on the play of chance, obtain a difference equal to plus or minus twice the standard error of the difference. Therefore, if the difference is more than twice its standard error, the probability is in favour of this difference not having arisen by mere chance. The difference may then be claimed to be "significant," though the actual origin of this "significance" has to be sought elsewhere.

It will be obvious that the greater the numbers in the samples, the more likely is it that significance for the difference, if any exists, will be established. Thus the percentage difference between the two races here studied for operative interference was $5.24 - 0.558 = 4.682$. The standard error of this difference is

$$\sqrt{\frac{5.24 \times 94.76}{5059} + \frac{0.558 \times 99.442}{1433}} = 0.37.$$

The difference of 4.682 is 12.77 times its standard error (0.37) and is, therefore, significant. If the samples were in the same proportion, say 10 Bantu and 35 Europeans, the standard error of the difference works out at 4.44. This standard error is almost equal to (1.05 times) the difference between the two samples. As a difference which is even twice its standard error may have arisen by chance, significance could not be claimed in the case of the small samples. It is to be noted, however, that with the samples of 1,433 and 5,059, the difference is in fact highly significant.

ANALYSIS.

Because 75.2 per cent of Europeans, and only 2.23 per cent of Bantu were delivered in hospital, it is obvious that the analysis of abnormal deliveries must be based on the totals of 5,059 European and 1,433 Bantu.

There is a significant difference (4.04 times its standard error) between the percentages of primigravidae in the two series. This means that any character which may be influenced by the fact that a patient is either a primigravida or a multipara cannot be considered on the basis of incidence percentage of the whole series, i.e. Bantu series or European series. The European primigravid incidence is about 6 per cent higher than that of the Bantu. Therefore there is a slightly greater probability of dystocia in the European than in the Bantu.

<i>European</i>	Total	5059	
Total primigravidae	1564		1564 in hospital
Total multiparae	3495		2238 in hospital
Total hospital cases			3802 or 75.2 per cent
<i>Bantu</i>	Total	1433	
Total primigravidae	364		12 in hospital
Total multiparae	1069		20 in hospital
Total hospital cases			32 or 2.23 per cent

1. *Operative Deliveries.* These include all assisted deliveries such as forceps, breech deliveries, and Caesarean section.

	European total 5059		Bantu total 1433	
	No.	Percentage of total	No.	Percentage of total
Hospital cases	3802	75.2	32	2.23
Operative cases	265	5.24	8	0.558
Percentage of hospital cases that had operative delivery		European	25.00	
		Bantu	6.96	

Percentage difference for operative deliveries $4.682 \pm 0.37 = 12.77 \times$ standard error. There is, therefore, a highly significant difference showing that the European requires assistance at delivery more often than the Bantu.

2. Forceps Delivery.

(a) High, mid, and low forceps delivery.

(i) Primigravidae and multiparae.

European	{ 73 primigravidae 19 multiparae
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Total 92, or 1.82 per cent

Bantu	{ 2 primigravidae 1 multipara
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Total 3, or 0.21 per cent

Total percentage difference = 1.61 ± 0.223
 $= 7.22 \times \text{standard error}$

(ii) Primigravidae only.

European 73, or 4.67 per cent of 1564

Bantu 2, or 0.55 per cent of 364

Difference 4.12 ± 0.66
 $= 6.26 \times \text{standard error}$

(iii) Multiparae only.

European 19, or 0.544 per cent of 3495

Bantu 1, or 0.094 per cent of 1069

Difference 0.450 ± 0.156
 $= 2.89 \times \text{standard error}$

(b) Low forceps delivery only.

(i) Primigravidae only

European 53, or 3.388 per cent of 1564

Bantu 1, or 0.275 per cent of 364

Difference 3.113 ± 0.535
 $= 5.82 \times \text{standard error}$

The above figures illustrate, first, the low forceps-rate of 1.82 per cent for Europeans. For some years it has been urged that our European forceps-rate is too low, and that an increase would be an advantage to resident students without militating against the principles of good obstetric practice. Compared with this low incidence in the European, the need for forceps delivery in the Bantu is significantly much less frequent, being 0.21 per cent as compared with over 5 per cent in most European communities elsewhere.

There is a statistical objection to grouping parous and primigravid women together because of the reason mentioned in the

section on Method: there is a significantly higher percentage of primigravidae in Europeans than in the Bantu, and the forceps-rate must always be higher in primigravidae. No claim will, therefore, be made for the difference which is as high as 7.22 times its standard error. It is seen, however, that for primigravidae alone (2, a, ii) there is a highly significant difference between the races, showing how infrequently forceps delivery is required in the Bantu. The corresponding figures for multiparae—difference = $2.89 \times \text{standard error}$ —is probably significant. There was only one case of forceps in 1,069 Bantu, and it is likely that in 2,000 Bantu there still would have been only one. It is submitted that the difference found is significant.

Forceps deliveries were recorded as being "low", "mid", and "high". The most reliable variety from the point of records is the "low" operation. Moreover, it was thought that a comparison on this basis would indicate whether the Bantu had as much difficulty in driving the head over the perineum as is known to be the case in the Europeans. The figures show that the low forceps operation was performed significantly more often in the European than in the Bantu.

3. Caesarean Section.

Total European 28, or 0.554 per cent of 5059

Total Bantu 3, or 0.209 per cent of 1433

Difference 0.345 ± 0.159
 $= 2.17 \times \text{standard error}$

European

primigravidae 10, or 0.64 per cent of 1564

Bantu primigravidae 2, or 0.55 per cent of 364

Difference 0.09 ± 0.44
 $= 0.205 \times \text{standard error}$

No statistical significance can be claimed for the above figures. This would mean that European and Bantu rates for Caesarean section were similar. It is probably

justifiable to group primigravid and multiparous subjects, because section is not done more frequently on primigravidae: the reasons for the operation are so diverse that a mixed sample consisting of women pregnant for the first or a subsequent time may well be compared with another sample similarly composed. If this principle be admitted, then there is possible significance in the lower Bantu rate for the total series. It should be noted that the European rate for Caesarean section is very low.

4. *Maternity Mortality.*

European	6, or 0.119 per cent of 5059
Bantu	2, or 0.1394 per cent of 1433

$$\begin{aligned} \text{Difference} & 0.0204 \pm 0.11 \\ & = 0.19 \times \text{standard error} \end{aligned}$$

The difference is not significant. The European death-rate of just over 1 per thousand is unusually low.

5. *Foetal Mortality.*

It is necessary at this stage to consider the foetal death-rate because of the fortitude shown by the Bantu mother in delivering herself. The analysis thus far has demonstrated the superiority of the Bantu woman as a parturient. The question arises, therefore, whether as a result of these vigorous Bantu labours, at which there is so seldom any assistance, there is not a high foetal mortality.

(a) *Stillbirths* (excluding multiple pregnancies).

European	96, or 1.910 per cent of 5023
Bantu	49, or 3.505 per cent of 1398

$$\begin{aligned} \text{Difference} & 1.595 \pm 0.528 \\ & = 3.02 \times \text{standard error} \end{aligned}$$

This difference is significant. The reason for excluding multiple pregnancies from analysis 5(a) is that there is a mortality amongst twin and triplet foetuses which in-

validates sound comparison. The same does not apply with equal force to premature births for two reasons: one is that the premature foetus, unless macerated, is usually born alive; the second is that there is no reliable criterion for prematurity, and hospital records are misleading on this point.

Although the Bantu stillbirth-rate is significantly higher than the Johannesburg European, it is low as compared with other large European series. The most favourable figure encountered is that of De Lee,¹ who showed that at his Chicago Hospital the figure had been reduced to 2.14 per cent in 51,422 births. The Bantu and Chicago percentage difference is 2.76 times its standard error. This is probably significant, though the significance is of a low order, a fact which is further illustrated by a comparison with other white race figures. Thus the British figure of 4 per cent is higher than that of the Bantu at 3.5 per cent. Figures from the U.S.A. and Germany vary between 4 and 5 per cent,² and it is noteworthy that as early as 1877 the stillbirth-rate in the U.S.A. was 5 per cent.³ It is seen, therefore, that in spite of the lively Bantu labours, the foetal mortality is low: it is significantly higher than that of the Johannesburg European series, because of the fact that the latter shows even a lower stillbirth-rate than that of De Lee.¹

(b) *Neonatal mortality.* The European and Bantu percentages for recorded neonatal deaths were respectively 0.74 and 0.86. The true percentage must be higher in each case, because the recorded deaths have occurred only during the lying-in period.

6. *Uterine Action.*

(a) *Uterine Inertia.* The recorded figures for inertia have been found too unreliable to analyse. The error is due to omission of cases,

(b) *Manual removal of the placenta.*

European	48, or 0.95 per cent of 5059
Bantu	3, or 0.209 per cent of 1433
Difference	0.741 ± 0.185
	$= 4.02 \times \text{standard error}$

The European figure for manual removal of the placenta is reasonable, and the above difference indicates that this operation is rarely required in the Bantu.

(c) *Postpartum haemorrhage.* The amount of blood loss was measured precisely in the case of those Europeans who were delivered in hospital. European cases on district with pronounced loss were transferred to hospital. For this analysis a haemorrhage of 40 ounces or more was considered. Amongst primigravidae there were 42 and amongst multiparae 60 women who had a haemorrhage ranging between 40 and 100 ounces. The total of 102 represents 2.02 per cent of the whole series.

On the district 97.7 per cent of Bantu women were delivered, and records relating to postpartum haemorrhage could not be used for statistical purposes. The general impression is that postpartum haemorrhage is uncommon, and it is certain that very few cases required blood transfusion.

MISCELLANEOUS.

7. *Breech Presentation.*

European	89, or 1.75 per cent of 5097
Bantu	19, or 1.31 per cent of 1446

$$\begin{aligned} \text{Difference} & 0.44 \pm 1.11 \\ & = 0.39 \times \text{standard error} \end{aligned}$$

The difference is not significant.

8. *Multiple Pregnancy.*

Twins

European	36, or 0.712 per cent of 5059
Bantu	16, or 1.120 per cent of 1433

$$\begin{aligned} \text{Difference} & 0.408 \pm 0.315 \\ & = 1.3 \times \text{standard error} \end{aligned}$$

The difference is not significant.

In addition to the twins, there was one set of triplets in each series. The Europeans were all stillborn, and the Bantu triplets were alive at 2 years of age.

DEATHS.

European. There were 6 deaths.

(i) A para 3 died on the 7th day of the puerperium. She had had an excessive postpartum haemorrhage, and the placenta was removed manually.

(ii) A para 1 died on the 18th day of the puerperium as the result of puerperal sepsis. The delivery was normal, with the birth of a live child.

(iii) A multipara with a twin pregnancy died of obstetric shock a few hours after labour.

(iv) A primigravida died undelivered as a result of congestive cardiac failure. She attended the antenatal clinic only once, 2 weeks before admission and 4 weeks before her death.

(v) A primigravida died 1 hour after low forceps delivery. On admission she had gross cardiac failure, and autopsy showed the presence of acute rheumatic endocarditis. The patient had been sent from a long distance, and was transferred to hospital from the clinic without delay. Labour commenced 2 days after admission.

(vi) A primigravida died 14 hours after Caesarean section. The patient had mitral and aortic valve incompetence, and was admitted in early cardiac failure. She was in labour with the head above the brim, and it was thought that Caesarean section would be the best method of treatment. Ten hours later she developed left-sided failure and died 4 hours later.

The first three deaths were preventable, and the last three were cardiac cases. Cases iv and v attended the antenatal clinic only once, and Case iv did not carry out the instructions given at the clinic: she failed to

report at the hospital as an in-patient and was not seen for a month prior to admission.

Bantu. There were 2 deaths.

(i) A primigravida aged 17 years was admitted to hospital in cardiac failure with swollen feet, a moderate degree of cyanosis and dyspnoea. She had a normal delivery after a prolonged labour, developed lobar pneumonia, and died 4 days after delivery.

(ii) A multipara was delivered of a macerated foetus and died soon after delivery. The cause of death was not obvious; but the lochia were very offensive and frothy, and obstetric shock was thought to be an important factor in causing the death of this toxic patient.

DISCUSSION.

The antenatal clinic figures shown in this paper compare very favourably with those reported elsewhere. The main feature to emerge from the analysis is the marked ability of the Bantu woman to deliver herself without assistance.

The Bantu female pelvis is slightly smaller than that of English women. Ince and Young⁴ found the average area of the brim in London English women to be 126.8 sq. cm., whereas the corresponding Bantu figure was 101.23, the largest brim of a series of 67 dry pelves⁵ being equal to Ince and Young's average. The size of the Bantu head at birth was shown by Heyns⁶ to be equal to that of white races. Therefore, all things being equal, the Bantu parturient should have a lower incidence of spontaneous births than the European woman.

Whereas 5.24 per cent of European parturients required operative interference, only 0.558 per cent of the Bantu women required assistance at delivery. The percentage difference of 4.682 is 12.77 times its standard error, and this is highly significant. Thus, even though she has to expel a

head of the same size as that in the European through a birth canal which is smaller than that of the European, the Bantu parturient shows a pronounced superiority in labour. This is further borne out by the significantly low forceps-rate of 0.21 per cent for the Bantu series. When low forceps delivery in primigravidae alone is considered, it is found that the European requires instrumental delivery more often than the Bantu with a 3.113 per cent difference which is 5.82 times its standard error. This significant difference emphasizes the fact that the Bantu is better able to drive the head over the perineum than is the case with the European. There is no doubt that the European, if it is a matter of necessity, can expel the head through the pelvic outlet; but in the case of the Bantu woman there is, in her opinion, no alternative to spontaneous labour: she believes that failure to deliver herself means death. This outlook can have only a salutary effect on the process of parturition, and avoids much of that interference in the European which the obstetrician knows to be dangerous and fundamentally unnecessary. There can be little doubt that civilization and too great a dependence on the doctor has reduced the efficiency of the European parturient.

Heyns⁷ has shown that, whereas the greatest cross-section of the well-flexed foetal head is about 70 sq. cm., the Bantu woman can, nevertheless, expel such a head through pelvic planes less than 80 sq. cm., and in a few cases even less than 70 sq. cm. This is illustrated by a remarkable case of the present series. This was a woman of 27 years who had had a Caesarean section for her first pregnancy. It had been explained to her that another section would be absolutely necessary, for the pelvis had been found to have the following dimensions:

Areas (sq. cm.): cavity 71.7, brim 75.4, outlet 64.5.

Brim index: 98.9 (conjugate 9.5 cm., transverse 9.6 cm.).

Outlet diameters: intertuberal 10.1 cm., interspinal 10.4 cm., and pubosacral 9.1 cm.

The patient sent for help after the baby had been born. There was extensive perineal laceration. The baby was a female weighing $6\frac{1}{2}$ pounds, and the head was moulded into a misshapen mass. The infant died an hour after birth.

Several of these interesting experiments became possible in Alexandra Township. It would be inhuman to allow trial labour in such cases, but in their desire to deliver spontaneously these women often avoided sending for help until labour was well advanced or completed. This has led to the view that there is danger in allowing uterine powers to have full sway under such circumstances, because of the risk to the foetus. This makes contracted pelvis as an indication for Caesarean section more difficult to assess, it being obvious that mere ability or failure on the part of the mother to deliver herself is no criterion having regard to the safety of the foetus.

In view of these facts, consideration of maternal and foetal mortality is demanded. In this series there was a Bantu maternal death-rate of 1.394 per thousand, and a Bantu stillbirth-rate of 3.505 per cent. These figures have been shown to compare favourably with the best figures from Europe and America.

From the above analysis it must be concluded that the Bantu parturient exhibits considerable superiority over the European. This refers to the Bantu under home conditions. It will now be necessary to

compare two large series of hospital patients, Bantu and European, in order to assess the effect of hospitalization on the emotional reactions of the parturient. It is our impression that in hospital the Bantu is a less efficient parturient than the European woman, whereas we have proved that in her own home she is greatly superior.

SUMMARY.

1. An analysis has been made of 1,433 Bantu and 5,059 European antenatal patients seen over a period of 5 years.

2. A highly significant statistical difference for operative delivery was found, and shows that the European requires assistance at delivery more often than the Bantu.

3. Maternal and foetal mortality were low in both series.

4. Other features concerning parturition were analysed; and it has been proved that the Bantu in her own home is a more efficient parturient than the European woman.

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The Blood in Pregnancy

PART II. THE BLOOD VOLUME, CELL VOLUME AND HAEMOGLOBIN MASS

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THE blood volume of normal adults has generally been assumed to bear a very constant relation to the body size, except in the case of pregnancy. Here it has long been known that changes in volume occur, but the extent of these changes has not been clearly established. Early work on the problem was subject to the criticism that the methods were unreliable, nevertheless it was clear in each case that a substantial increase in the blood volume did occur during pregnancy.^{1, 2, 3}

All criteria of the normality of the blood constituents are based on their level in the blood, but it seems probable that the most important factor physiologically is their level in the whole body which they have to supply. So long as the blood volume bears a constant relation to body size, the blood level will give a quantitative indication of the amount of the blood constituents in the body, but when the blood volume varies, as it does in pregnancy, it is obvious that the relationship will not hold, and it will not be possible to deduce the amounts present in the body from their levels in the blood.

The present work was undertaken to investigate the extent of the variations in blood volume which occur during preg-

nancy, to discover how these variations affect the total amounts of haemoglobin and red blood cells, and whether their levels in the blood, under the new conditions, give any indications of their levels in the body.

It was first necessary to confirm the fact of a constant relationship between blood volume and body size in non-pregnant women and to decide what measurement gave the best criterion of size. The first study of this subject was that made by Rowntree and Brown⁴ who investigated 49 men and 25 women and showed that the blood volume bore a constant relation to the surface area, which is a function of the height and weight. The relation between blood volume and weight was not so constant. Gibson and Evans⁵ studied 49 men and 41 women and considered the relation between the blood volume, height, weight and surface area. They did not investigate statistically which measurement gave the best correlation, but if this is done it is apparent that the correlation of blood volume with surface area is slightly better than that with weight. These results and those to be reported suggested that the surface area was the most useful criterion of body size.

The question of the criterion of body size

during pregnancy is complicated by several factors. The weight of the pregnant woman includes that of the foetus which has its own independent blood supply, so that this measurement gives too high values. In spite of this fact numerous workers have used weight, but Dieckmann and Wegner² when they found that in many cases the concentration of blood per kilogram apparently fell during pregnancy, abandoned all attempts to allow for changes in the maternal size and considered all results from the point of view of the percentage changes in absolute amounts. Some allowance for maternal changes and for individual variations in size seems, however, desirable, and here the surface area has been used in pregnant, as in non-pregnant women. The error due to inclusion of foetal tissue is not so great as with weight, as the formula from which the surface area is derived depends on the height more than on the weight

$$(\text{Area} = \text{Weight}^{0.425} \times \text{Height}^{0.725} \times C).$$

It is realized that this formula, owing to changes of shape during pregnancy, probably does not give the actual surface area, but it was considered to give the most satisfactory values available.

Part A of this work records the results of an investigation of the blood volumes of 20 normal non-pregnant women. The relation of the blood volume to body size is considered, together with the relation between the levels of haemoglobin and cells in the blood and in the body.

In Part B the results of blood volume and full blood investigations of 20 women at 3 different stages of pregnancy are reported. The changes in absolute amounts of blood, haemoglobin and cells are considered, together with their changes in concentration in the body and the changes of concentration of haemoglobin and cells in the blood.

METHODS.

The blood volumes were estimated by the dye method, using Evans blue (T-1824) and the technique described by Davis.^{3a} The subjects after a breakfast containing no fat, came to hospital and were rested for 30 minutes before the test. While still recumbent, 5 ml. of a 240 mg. per 100 ml. solution of dye in normal saline was injected into one arm vein and blood removed from the other arm 10 minutes later. The dye concentration in the serum was estimated with a 'Spekker' photo-electric absorptiometer, by comparison with a standard solution made up with serum obtained before dye injection. From this the plasma volume was calculated. Blood volumes obtained by this method theoretically may be accurate to within 5 per cent. The normal blood volume can thus be estimated within 200-250 ml.

Blood was collected at the first venepuncture in a Wintrobe tube and used for determination of the haemoglobin concentration, red blood cell count and haematocrit. The haemoglobin was determined with a Haldane haemoglobinometer, the apparatus being standardized by the National Physical Laboratory. The Haldane haemoglobinometer was calibrated so that 100 per cent represented 13.8 g. per 100 ml. From the haematocrit and plasma volume were calculated the total blood volume and cell volume and from the haemoglobin concentration and blood volume the total haemoglobin mass.

It has recently been suggested by Cruikshank and Whitfield⁶ that some of the dye when first injected is taken up by the reticulo-endothelial system and does not appear in the circulating blood. If this is so the blood volumes obtained will be too high. The conclusion was based on animal experiments and would not appear, from the following test, to hold for man. Three

normal women received 2 injections of 12 mg. of dye at 10 minutes intervals. The concentrations of dye 10 minutes after the first injection and 10 minutes after the second were 0.55 and 1.11 mg./100 ml., 0.48 and 0.90 mg./100 ml. and 0.58 and 1.10 mg./100 ml. The concentration in the second sample was thus in every case approximately twice that in the first, and there was no evidence that any of the first lot of dye had not entered the circulation.

It has been suggested that the rate of mixing of dye in the plasma and its rate of elimination differ from the normal in pregnancy. Thus Graff *et al.*⁷ found that in 2 pregnant women the mixing time of vital red was prolonged from the normal of 6 minutes to 9 and 10 minutes. Before mixing was complete, high concentrations of dye were present. In order to investigate these points 3 women in the third trimester of pregnancy had samples of blood removed at varying times after the dye injection. The following dye concentrations per 100 ml. of blood were found: first case, 5 min., 0.41 mg.; 10 min., 0.36 mg.; 20 min., 0.37 mg.; second case, 5 min., 0.29 mg.; 10 min., 0.24 mg.; 20 min., 0.24 mg.; third case, 10 min., 0.29 mg.; 15 min., 0.29 mg. The first 2 cases showed the initial high concentration, before mixing was complete, but by 10 minutes this was over and 15 and 20 min. samples showed no further dilution. The fact that there was no fall in concentration in the second 10 minutes indicated that during pregnancy the dye was not removed from the circulation with abnormal rapidity. If a loss occurs to the placental circulation it must either be immediate or else very slow. It should be noted that Thomson *et al.*³ could find no Evans blue in amniotic fluid, cord blood or placental membranes when it had been injected into the maternal circulation shortly before parturition.

NON-PREGNANT WOMEN.

The details of the findings are shown in Table I. There were considerable variations in the total blood volumes of the 20 women investigated, but these were closely correlated with variations in the surface area (correlation coefficient 0.898, standard error 0.190). There was, therefore, little variation in the blood volume per square metre, the mean value for which was 2,660 ml. with a standard deviation of 163 ml. The correlation between blood volume and body weight was not as close (correlation coefficient 0.694, standard error 0.170). The mean blood volume per kilogram was 74.5 ml. with a standard deviation of 6.8 ml.

The mean blood haemoglobin level of the cases was 93 per cent, standard deviation 8.65 per cent. There was a slight tendency for low haemoglobin levels to occur when the blood volumes were high, but the correlation coefficient of -0.129, standard error 0.235, was not significant. The mean total haemoglobin mass was 340 g. per square metre, standard deviation 35 g. There was a close correlation between the level of haemoglobin in the blood and that in the whole body, the correlation coefficient being 0.843, standard error 0.127.

The mean haematocrit was 42.3 per cent, standard deviation 3.9 per cent. There was no correlation of haematocrit with blood volume. The mean total cell volume was 1,130 ml. per square metre, standard deviation 115 ml. The proportion of cells in the blood was correlated with the cell volume per square metre, the correlation coefficient being 0.817, standard error 0.136.

CONCLUSIONS.

The blood volumes of 20 normal non-pregnant women were found to vary

with their surface area, the mean amount per square metre of surface area being 2,660 ml. Since this relationship was reasonably constant, the level of cells and haemoglobin in the body was proportional to their level in the blood.

The value of 2,660 ml./sq. m. (standard

PREGNANT WOMEN.

Twenty women were followed throughout normal pregnancies. They were all but one attending the hospital antenatal clinic and were chosen as being normal cases in the early months of pregnancy. The number able and willing to co-operate

TABLE I.

The Surface Area, Blood Volume and Haemoglobin and Cell Concentrations in 20 Normal Women.

Case No.	Surface area sq.m.	Blood volume, ml. ml./sq.m.		Haemoglobin, per cent	Haematocrit, per cent
1.	1.36	4100	3000	100	47
2.	1.47	3800	2550	92	43
3.	1.48	4100	2750	78	38.5
4.	1.50	3900	2600	98	45
5.	1.51	3900	2600	92	40
6.	1.52	3800	2500	98	46
7.	1.53	3800	2500	94	44
8.	1.54	4100	2650	82	37
9.	1.58	3900	2450	98	43.5
10.	1.59	4200	2650	88	39
11.	1.60	4100	2550	112	49
12.	1.63	4100	2500	76	35.5
13.	1.64	4100	2500	96	42
14.	1.71	4600	2700	92	41
15.	1.71	4700	2750	96	44
16.	1.72	4500	2600	98	49
17.	1.77	4900	2800	104	45
18.	1.89	5600	2950	82	38
19.	1.90	5700	3000	90	40
20.	1.91	5100	2650	90	39

deviation, 163) may be compared with that found by Rowntree and Brown⁴ in 25 normal women, which was 3,130 ml./sq. m. (standard deviation, 276) and also with the figure of 2,460 ml./sq.m. (standard deviation, 240) which may be calculated from the results of 39 cases reported by Gibson and Evans.⁵ With the latter figure there is a fair agreement but that of the earlier workers is considerably higher.

was not large and for this reason it was necessary to use some cases seen first as late as the 16th week. First tests were made between the 8th and 16th week, mean 12.4 weeks; second, between the 20th and 27th weeks, mean, 24.2 weeks and third between the 33rd and 38th weeks, mean 35.6 weeks. The ages of the women varied from 20-39 years, mean 28.2 years. Seventeen were primiparae and 3 multiparae.

(1) *The Concentration of Haemoglobin and Cells in the Blood.*

The mean haemoglobin concentration, haematocrit and red blood cell count of the women at each of 3 tests are shown in Table II, together with the mean corpuscular haemoglobin content, mean cell haemoglobin, colour index and mean cell volume.

per cent. This fall was parallel with the fall in haemoglobin as was shown by the fact that the mean corpuscular haemoglobin, or concentration of haemoglobin in the cell mass, altered little, it was 30.4 per cent, 31 per cent and 31.1 per cent at the 3 tests. Individually there was little variation in the M.C.H.C. as is shown by the small standard deviation.

TABLE II.

The Mean Blood Findings in 20 Women at Three Stages of Pregnancy.
Cases having iron in parenthesis.

No.	Mean duration of pregnancy				
	12.4 weeks		24.2 weeks		35.6 weeks
	20	20	(3)	20	(4)
Haemoglobin g./100 ml.	12.0	11.5		11.3	
Standard deviation	1.3	1.2		0.8	
Per cent of normal	86.6	82.6	(83.3)	82.1	(83.5)
Haematocrit, per cent	39.2	37.0	(37.8)	36.4	(36.7)
Standard deviation	3.2	2.0		2.2	
R.B.C.s m./c.mm.	4.47	4.15	(4.21)	4.15	(4.09)
Standard deviation	0.42	0.25		0.39	
M.C.H.C. g./100 ml.	30.4	31.0	(30.3)	31.1	(31.4)
Standard deviation	1.8	1.3		1.7	
M.C.H. yy	26.2	27.4	(27.5)	27.3	(28.2)
Standard deviation	2.6	2.0		2.1	
Colour index	0.97	1.00	(1.02)	1.00	(1.04)
M.C.V. cμ	87.9	88.5	(90.4)	88.1	(90.2)
Standard deviation	6.3	6.2		7.2	

Haemoglobin concentration. This fell throughout pregnancy in those cases with initially high values and remained constant when the initial values were low. Five cases showed a rise or no change between the first and last tests, the remainder showed a fall. The mean values at the 3 tests were 86.6 per cent, 82.6 per cent and 82.1 per cent, or 12.0 g., 11.5 g. and 11.3 g. per 100 ml.

Haematocrit. The volume of cells in the blood fell during pregnancy in 18 out of the 20 cases. The mean figures at the 3 tests being 39.2 per cent, 37.0 per cent and 36.4

Red blood cells. These also fell, in 16 out of the 20 cases, and the means at the 3 tests were 4.47 mil., 4.15 mil., and 4.15 mil. The fall was similar to that of haemoglobin concentration, the mean cell haemoglobins being 26.2 yy, 27.4 yy and 27.3 yy, and the colour indices 0.97, 1.00, and 1.00. There was thus no tendency for hypochromia to develop. The lowest colour indices at the final test were 0.87 and 0.88, and all the others were greater than 0.90. The mean cell volumes were 87.9 cμ, 88.5 cμ and 88.1 cμ. There was thus no appreciable change in the cell size.

Cases who received Iron.

Two of the women, whose haemoglobins when first seen were 72 per cent and 62 per cent respectively, were treated with iron. Two others were given iron by their own doctors. The mean values of these cases are shown in Table II in parenthesis. The case with an initial haemoglobin of 62 per cent and colour index of 0.74, thereafter had a haemoglobin of 94 per cent and colour index over unity. In the others, who did not originally show hypochromia, the haemoglobin did not rise above 82 per cent and a comparison with other cases with similar values makes it extremely doubtful whether the iron medication had any effect.

Blood volume. There was an increase in the blood volume between the first and third tests in every case. This increase was not always steady throughout, in 4 cases the volume fell between the first and second tests and in another 3 it fell between the second and third tests. The increase was extremely inconstant in amount, the difference between the first and third tests ranging from 200 ml. to 2,800 ml. The mean values at the 3 tests were 4,300 ml., 4,900 ml. and 5,400 ml.

Haemoglobin mass. There was a significant increase in the haemoglobin mass between the first and third tests in 14 out of the 20 cases. The increase varied from 50-360 g. In the remaining 6 cases the

TABLE III.

Mean Variations in Blood Volume, Cell Volume and Haemoglobin Mass in 20 Pregnant Women and their Relation to Changes in Surface Area.

		Mean duration of pregnancy, weeks				
		12.4	24.2		35.6	
		Per cent change			Per cent change	
<i>Absolute mean values.</i>						
Surface area, sq. m. ...	...	1.58	1.64	4	1.70	8
Standard deviation	...	0.10	0.10		0.10	
Blood volume, ml. ...	...	4300	4900	15	5400	26
Standard deviation	...	400	650		800	
Haemoglobin, g. ...	...	515	560	8	610	19
Standard deviation	...	65	95		90	
Cell volume, ml. ...	...	1650	1800	8	1950	18
Standard deviation	...	200	350		250	
<i>Mean values per sq.m. surface area.</i>						
Blood volume, ml. ...	...	2700	2975	10	3180	18
Standard deviation	...	210	325		400	
Haemoglobin, g. ...	...	320	340	6	360	12
Standard deviation	...	45	45		40	
Cell volume, ml. ...	...	1060	1100	4	1160	9
Standard deviation	...	125	160		120	

(2) *The Blood Volume, Haemoglobin Mass and Cell Volume.*

(a) *Absolute amounts.*

The mean values and their standard deviations are shown in Table III.

change in haemoglobin mass was less than 30 g. and insignificant. The mean values at the 3 tests were 515 g., 560 g. and 610 g.

Cell volume. Three cases had final cell volumes lower than the initial volumes, in

2 cases there was no change. In the other 15 cases the cell volume increased by 100–800 ml. The mean values at the 3 tests were 1,650 ml., 1,800 ml. and 1,950 ml.

(b) *The levels of blood, haemoglobin and cells in the body.*

The variations in the absolute values are to some extent due to the different body sizes of the subjects. A more accurate comparison of the results is obtained if the blood volume, haemoglobin mass and cell volume per square metre of body surface are considered. The means for these values are also shown in Table III.

Blood volume level. The mean values at the first, second and third tests during pregnancy were 2,700 ml./sq.m., 2,975 ml./sq.m. and 3,180 ml./sq.m., compared with 2,660 ml./sq.m. for non-pregnant women. Although there was a considerable difference between the means at the 3 tests, in many cases the blood volume at the end of pregnancy was not outside the range of the values found in the non-pregnant women. This overlap is apparent from the standard deviations (Table III). The standard deviations also showed that the blood volume became more variable as pregnancy advanced. Thus the standard deviation from the mean for non-pregnant women was 163, for the first test in pregnancy it was 210, for the second 325 and for the third 400. From this it is apparent that in the later months of pregnancy the blood volume could not be predicted with any accuracy, even when account was taken of the body size.

There was no significant difference between the mean blood volume at the first test in pregnancy and the mean blood volume of non-pregnant women. This suggested that in the early months of pregnancy there was little change in the volume. A comparison of different groups of women when the numbers are so

small is not, however, reliable. The alterations in blood volume in the early months are difficult to investigate as the value prior to pregnancy is not known. The postpartum value is probably the best available measure of the non-pregnant blood volume, if it is obtained several weeks after parturition, when any blood loss has been made good. Two women were investigated 5 weeks postpartum. The blood volume of the first was 2,650 ml./sq.m. postpartum and 2,850 ml./sq.m. when 8 weeks pregnant. This was a difference of 8 per cent. That of the second was 2,600 ml./sq.m. postpartum and 2,950 ml./sq.m. when 13 weeks pregnant. Here there was a difference of 13 per cent.

Haemoglobin and cell levels. The mean values for haemoglobin per square metre were 320 g., 340 g. and 360 g. at the 3 tests during pregnancy. The mean cell volumes per square metre were 1,060 ml., 1,100 ml. and 1,160 ml. at the 3 tests. The haemoglobin mass and cell volume did not show the increasing variability exhibited by the blood volume. This is shown by the fact that the standard deviations did not increase.

(c) *The increases in blood volume, haemoglobin mass and cell volume.*

The increases in haemoglobin mass and cell volume during pregnancy were proportionately less than the increase in blood volume. Thus when the values per square metre are considered it is seen that between the first and second tests during pregnancy the blood volume increased by 10 per cent, the haemoglobin mass by 6 per cent and the cell volume by 4 per cent, while between the first and third tests the blood volume increased by 18 per cent, the haemoglobin mass by 12 per cent and the cell volume by 9 per cent.

The significance of these increases was investigated statistically and the results are

shown in Table IV. Only 19 of the 20 cases were considered as the case with an initial hypochromic anaemia, who responded to iron medication with an increase of haemoglobin and cells, was excluded. It will be seen that the increase in blood volume was significant at both the second and third tests. The increase in haemoglobin mass and the increase in cell volume were only significant by the third test.

the levels of haemoglobin and cells in the blood and their total amounts. The correlation coefficient for haemoglobin was 0.145, standard error 0.233 and that for cells was 0.025, standard error 0.236. These figures may be compared with those for non-pregnant women. The correlation coefficient for haemoglobin was then 0.843, standard error 0.127, and that for cells 0.817, standard error 0.136. On the other

TABLE IV.
The Increase in Blood, Cell and Haemoglobin Concentration in the Body During Pregnancy (19 cases).

Per sq. m. surface area	Initial values	Mean increase at Second test			Mean increase at Third test		
		St.E.	t.		St.E.	t.	
Blood volume, ml.	2700	280	80.65	3.47	475	94.60	5.02
Cell volume, ml.	1070	10	40.80	0.24	80	35.14	2.22
Haemoglobin, g.	323	14	11.47	1.19	29	10.20	2.84
The increase is significant when t is greater than 2.11.							

The increase is significant when t is greater than 2.11.

(3) *The Relation of the Levels of Haemoglobin and Cells in the blood to their amounts in the Body.*

As pregnancy advanced the total amounts of haemoglobin and cells rose, but owing to the disproportionate increase in the total plasma the levels of haemoglobin and cells in the blood fell. The percentage haemoglobin and haematocrit during pregnancy did not, therefore, bear the same relation to the total amounts of haemoglobin and cells as they had in non-pregnant women. If the increase in blood volume had been constant in amount in all pregnant women, it would have been possible to find, for the different stages of pregnancy, the blood levels which represented normal total amounts of haemoglobin and cells. Since, however, the increase in blood volume was very variable this was not possible. It was in fact found that, by the third trimester of pregnancy, there was little or no correlation between

hand it was apparent that the haemoglobin and cell levels in the blood by the third trimester of pregnancy were inversely correlated with the blood volume. The correlation coefficient of haemoglobin percentage on blood volume per square metre was -0.532, standard error 0.120, while that of haematocrit on blood volume per square metre was -0.560, standard error 0.130. Both these coefficients were significant, while the corresponding ones for non-pregnant women were not.

(4) *Two Cases Exhibiting Anaemia During Pregnancy.*

(a) *Hypochromic anaemia.*

This patient was one of those originally selected for investigation as a normal case. The values found during the first and second trimesters were similar to those found in other pregnant women. When the third test was carried out at the 36th week it was found that the haemoglobin had fallen from

80 per cent at the second test to 70 per cent. This value was not abnormally low for this stage of pregnancy, but when the blood volume was estimated it was found that this had fallen from 3,100 ml./sq.m. to 2,700 ml./sq.m., so that the haemoglobin mass was now only 260 g./sq.m. as compared with 350 g./sq.m. at the second test and the cell volume was only 900 ml./sq.m. as compared with 1,100 ml./sq.m. Thus while the blood haemoglobin level had decreased by 12 per cent, the total haemoglobin had decreased by 24 per cent. The cell volume had decreased by only 18 per cent, so that there was a fall in the colour index which was now 0.73.

(b) *Pernicious anaemia of pregnancy.*

This case was found to have a severe megalocytic anaemia when 29 weeks pregnant. Her blood haemoglobin level was 28 per cent, haematocrit 13 per cent and colour index 1.33. She had a blood volume of 3,000 ml./sq.m., which was normal for this stage of pregnancy, but a total haemoglobin mass of only 120 g./sq.m. and cell volume of 400 ml./sq.m. After 4 weeks treatment the blood haemoglobin level was 66 per cent, haematocrit 34 per cent and colour index 1.11. The blood volume had now fallen to 2,500 ml./sq.m. Since during the same time there had been a fall of 1.5 kg. in weight, owing to loss of oedema fluid, it seems that the original high blood volume may have been due to a hydraemia, not to a true pregnancy increase. The haemoglobin mass was now 230 g./sq.m. and the cell volume 850 ml./sq.m. After 8 weeks treatment the haemoglobin was 72 per cent, the haematocrit 36 per cent, and colour index 0.92. The blood volume had risen again, to 3,400 ml./sq.m. and the total haemoglobin and cell volumes were 340 g./sq.m. and 1,200 ml./sq.m., normal values for this stage of pregnancy. Between the second and the final estimations the

blood haemoglobin level thus showed an increase of 9 per cent and the haematocrit an increase of 6 per cent! But since there had been a marked increase in the blood volume, the haemoglobin mass had increased by 48 per cent and the cell volume by 41 per cent.

CONCLUSIONS AND DISCUSSION.

The changes which occurred in the peripheral blood of the 20 pregnant women investigated, were a fall in haemoglobin concentration, cell volume and cell count, which were parallel so that there was no appreciable change in the mean corpuscular haemoglobin content, colour index or mean cell volume, all of which remained within normal limits. These changes are similar to those found in previous complete blood examinations of normal pregnant women.^{2a, 2b, 8, 9, 10, 11} Iron administration failed to raise the haemoglobin level unless the colour index was low. This also has been found previously.^{10, 12}

The blood volume was found to increase throughout the course of pregnancy. The increase was more than could be accounted for by alterations in body size. The haemoglobin mass and cell volume also increased, but only slightly more than would be expected from the increase of body size. This might be accounted for by the vascularity of the new tissues formed. The mean values found for the blood volume during pregnancy agree well, when calculated as volume per square metre of body surface, with those recorded by Dieckmann and Wegner,² and Thomson *et al.*³ The 3 sets of values are shown and compared in Fig. 1.

The total amount by which the blood volume rose during pregnancy was difficult to determine, since values before pregnancy were not available. Postpartum values were the only possible indication of the original blood volume. These were

obtained in two cases and were considerably lower than the values in the same women during the first trimester of pregnancy. Dieckmann and Wegner² and Thomson *et al.*³ also found this. It would therefore appear that the increase in blood volume starts early in pregnancy and that the total rise is greater than that observed between the end of the first trimester and the last months.

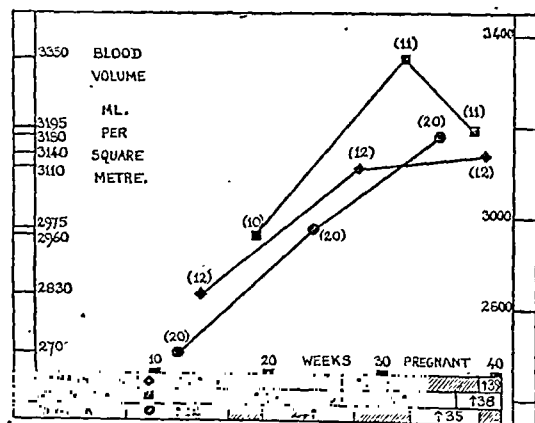


FIG. 1.

THE MEAN BLOOD VOLUME AT DIFFERENT STAGES OF PREGNANCY.

The blood volume is expressed as ml. of blood per square meter of body surface. The present results are compared with those of two previous studies. The numbers of cases in each group are shown in parenthesis and at the bottom of the figure are shown the periods during which each group was investigated and the mean time of investigation.

There were large variations in the amount of the increase in blood volume observed during pregnancy and no reason could be found for this. There was no correlation between the size of the increase and the age of the subjects, size of child and placenta, or with blood-pressure levels. This variability of the increase in blood volume was also noted by Dieckmann and Weg-

ner.² The increases observed by Thomson *et al.*³ were more constant.

The fall in the level of haemoglobin and cells in the blood during normal pregnancy was due to the fact that the plasma volume increased more than did the haemoglobin mass and cell volume. The small variations in the haemoglobin level in the blood, seen in the women in the third trimester, were due to variations in the blood volume, rather than to variations in the total haemoglobin.

In abnormal cases, however, a fall in haemoglobin level in the blood may be due to a decrease in the total haemoglobin. This was so in the two anaemic cases investigated. These cases also illustrated the difficulty of assessing the degree of anaemia in pregnancy from the blood haemoglobin level alone. The presence of anaemia was, however, apparent from further examination of the peripheral blood, the colour indices being in each case abnormal.

These findings may be employed to explain the changes in the haemoglobin level in the blood found in a larger series of women from the same antenatal clinic, who were investigated over the same period in 1944. The results of that investigation were recorded in our previous paper.¹¹ The haemoglobin level of the women fell steadily throughout pregnancy till the last weeks. It now appears that this fall was due to an increase in blood volume, the plasma increase being out of proportion to that of haemoglobin. In the last weeks the haemoglobin level rose in many of the women. No explanation of this terminal rise was obtained from the present results, but the rise was also found by Thomson *et al.*³ who were able to correlate it with a fall in the plasma volume.

It was also found in the larger series that the blood haemoglobin level of the older women tended to fall more than did that of the younger ones. The 20 women, investi-

gated in detail, did not show any variation with age, but this is not surprising with such a small number. It seems probable that the variation in blood haemoglobin level with age, in the larger series, was due to variation in the plasma volume. The alternative explanation is that there was an increasing failure of haemoglobin formation with advancing years. This appears unlikely in view of the fact that the effect of age was apparent throughout the series, so that the levels were lower even in women of 25 than in those of 20, and it is difficult to believe that there can have been any failure of haemopoiesis at such an early age. Fullerton,¹³ who also observed lower haemoglobin levels in older women, considered that they were due to these women having started pregnancy at lower levels than the younger ones. This explanation is not supported by the present results, which showed that the difference was due to a more rapid fall during pregnancy and only became apparent in the later months.

Although in normal women the fall in haemoglobin level during pregnancy was due to dilution of the haemoglobin mass with plasma, a fall may also occur as a result of failure of haemoglobin formation. This was the case in the two anaemic cases investigated. In our previous paper¹⁴ the haemoglobin levels of a series of pregnant women, seen in 1942, were reported. The levels were lower, all through pregnancy, than in 1944 and it is suggested that this was due to the combined effects of plasma dilution and deficient haemoglobin formation. This is supported by the fact that in 1942 the women who had been subjected to the strain of repeated pregnancies had lower haemoglobin levels than had the primiparae.

A satisfactory explanation of the increase in plasma volume during pregnancy has not yet been found. The present work did not provide any new evidence on the

point, so nothing can be added to the adequate discussions of previous investigators.

SUMMARY.

1. The blood volume was estimated by the dye method (Evans blue) in 20 non-pregnant women and in 20 women 3 times during pregnancy. Various criticisms of the method, both general and as applied to pregnancy, were explored and found not to be applicable.

2. The blood volume in normal non-pregnant women was proportional to the body size, as measured by surface area, so that the concentrations of haemoglobin and cells in the blood were proportional to their concentrations in the body.

3. The blood volume increased during normal pregnancy. There was an increase of whole blood to supply the added maternal tissues, but there was also a further increase of plasma.

4. The disproportionate increase in plasma resulted in a fall of haemoglobin and cell concentration in the blood, but the normality of the low levels resulting was confirmed by the fact that the concentration of haemoglobin in the cells and the size of the cells remained within normal limits.

5. The amount of the increase in plasma during pregnancy was very variable and in this series by the later months of pregnancy the levels of haemoglobin and cells in the blood reflected inversely the blood volume, rather than the level of these substances in the body.

6. Two cases of anaemia occurring during pregnancy are reported, illustrating how the changes in blood volume obscured the changes occurring in the solid blood elements.

7. The findings were applied to explain

the changes in haemoglobin level found in two larger series of women and reported on in the previous paper.

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A Survey of the Relation Between Epilepsy and Pregnancy

BY

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ALTHOUGH the epileptic convulsion has been known to the medical world since ancient times, the elucidation of its cause and mode of production has not yet been fully achieved. Aetiological factors such as cerebral trauma and organic disease have been recognized for centuries, and fits so caused are designated by the term "symptomatic epilepsy." Probably in the future the origin of all fits will become known and all epileptic convulsions will then be included in this category, but at present there exists a large group apparently unrelated to any causal disease. These fits, which comprise the 2 forms of *grand mal* and *petit mal*, are usually regarded as cases of "essential epilepsy" or "idiopathic epilepsy." It is these idiopathic fits that will be dealt with here, and their manifestations as encountered in the obstetric patient will be portrayed and discussed.

EPILEPSY IN OBSTETRIC LITERATURE.

It is agreed by almost all authorities that idiopathic epilepsy occurs in all races and has the same incidence in the 2 sexes. There are many statistics giving the ages of onset of fits, the most comprehensive being those of Turner.¹ In an analysis of 1,000 cases of epilepsy he showed that in 27.2 per cent fits began before the age of 9 years, in 55.7 per cent between 10 and 22, and in the remaining 17.1 per cent between 23 and 70 years. The average age of onset in males he found to be 13.7 and in females

15.5 years. He concluded that the age of 11 to 15 years was the most dangerous epoch, and this was so because of the influence of puberty. The frequency of fits is, of course, extremely variable from case to case, and is modified by the various drugs prescribed for their control, but is sometimes influenced by external factors. Thus, fits are said to occur less frequently in hot weather with the greatest incidence in May and October;² this seasonal influence was appreciated by Hippocrates who considered that they were most frequent in the spring. However, more apparent than these variations, are those which are known to be associated with menstruation. Thus, fits may occur only at the time of the period, either just before or during its course, but rarely just after it has ended; if they occur continuously, they may be more frequent at this time. This close association of menstruation with epilepsy was noted by Bachmann,³ who stated that during temporary sterilization induced by exposure of the ovaries to X-ray irradiation, there was a corresponding cessation of the fits. Sometimes a different type of clinical picture is seen. Kinnier Wilson⁴ described a patient who had a solitary fit at puberty which was not repeated until the time of the menopause, whilst similar cases recorded by Elliotson⁴ and Binswanger⁵ had epileptic fits regularly until the menarche, and then were free from them until the menopause. Perhaps more remarkable still was Filia's⁶ case, in which

a breast-fed infant had convulsions only when its mother was menstruating. Kinnier Wilson² recorded the case of a girl who had *petit mal* only at the time of her mother's periods, although he was forced to the conclusion that this must have been a coincidence.

Following upon marriage there is usually no change in the frequency of the epileptic fits, although Sachs⁷ and Muskens⁸ each reported cases which did improve after marriage. Strong emotion is known to be a factor which causes fits, and so it is to be expected that fits might be induced by sexual intercourse, this was so in the case presently to be described, although no less an authority than Kinnier Wilson considers that convulsions are unrelated to coitus.

Most authorities are of the opinion that epilepsy does not lower fertility, although Essen-Möller⁹ stated the contrary. Stander¹⁰ in his textbook gives an incidence of 0.14 per cent of pregnancies complicated by epilepsy, whilst Baptisti¹¹ recorded 37 cases amongst 54,688 patients; an incidence of 0.067 per cent. In the Obstetric Unit of the West Middlesex County Hospital there have been 21 cases of idiopathic epilepsy in the last 7 years, during which time there have been 14,349 deliveries, i.e., an incidence of 0.146 per cent. This of course cannot be considered the true incidence in the general population, as only patients with an apparent or suspected abnormality are booked and admitted.

Most-writers agree with Greenhill¹² that epilepsy usually has no effect on pregnancy. Thus Nerlinger¹³ had only 3 cases of abortion in 153 epileptic pregnancies, and 2 cases of premature labour in 102 pregnancies. Cases of abortions and premature labours following fits have however been reported, the highest incidence being recorded by Waldstein¹⁴ of 10 abortions and 4 premature labours occurring in 54 epileptic pregnancies.

When the effect of pregnancy on epilepsy is considered, a variable picture is seen in which the frequency of the fits may be either reduced or increased or may remain uninfluenced. Different writers have made widely different statements—thus Curschmann¹⁵ considered that patients usually improved, Binswanger⁵ that they usually became worse, and Baptisti¹¹ that they were usually unaffected. Amongst the worsened cases must be included those in which the convulsions may have been absent for years, only to be revived by the pregnancy. In Table I are given the statistics that are available on this point, together with those from the West Middlesex County Hospital.

TABLE I.
The Incidence of Fits During Pregnancy.

Observer	Better Per cent	Worse Per cent	No Influence Per cent
Nerlinger ¹³	35.6	36.2	11.5
Rubeska ¹⁶	33.3	33.3	33.3
Baptisti ¹¹	17.0	13.0	70.0
Béraud ¹⁷	50.0	—	—
Waldstein ¹⁴	50.0	—	—
West Middlesex County Hospital	5.5	42.0	52.5

It will be seen that there is no agreement amongst the authors. Probably Rubeska¹⁶ is as near the truth as anybody when he considers that one third of the cases improve, one third become worse, and one third remain unchanged. Turner¹ found that in 7 of his 21 cases which were adversely affected the relapse was associated with quickening.

It might be thought that the cases which were subject to convulsions at the times of the menstrual periods would be amongst those who became worse during pregnancy. Nerlinger¹³ showed that this was not so, as

some of his cases of menstrual epilepsy improved and others deteriorated during pregnancy. Baptisti¹¹ quoted 7 cases of menstrual epilepsy, 4 of whom improved during pregnancy whilst 3 remained unchanged. We must agree with Sachs⁷ that when pregnancy occurs in an epileptic mother it has an influence on the disease which is completely unpredictable. The effect may, in fact, differ in successive pregnancies in the same patient; this occurred in a case of Turner's who was free from attacks in 1 pregnancy, but had them more frequently in the next. Of the improved cases all observers are agreed that the relief is not permanent—Döderlein¹⁸ emphasized that epilepsy is never cured by pregnancy, although Muskens⁸ described a patient subject to fits from the time of puberty in whom they ceased entirely after her last labour.

Numerous cases are on record in which convulsions first occur during pregnancy, and these are referred to as cases of "pregnancy epilepsy." Echeverria,¹⁹ Gowers,²⁰ Bachmann,³ and Struthers²¹ all described cases of this type; sometimes the fits continue permanently after delivery, as in a case mentioned by Browne,²² where the residual convulsions were usually of the menstrual type, and sometimes they recur only during subsequent pregnancies. Nerlinger¹³ however denied that fits can begin during pregnancy, pointing out that there would not be an equal incidence in the sexes if pregnancy were an actual cause of the disease.

A relation between the incidence of fits and the sex of the child has often been suggested. Thus Pachelt,²³ Muskens⁸ and de la Motte²⁴ all described patients who had repeated pregnancies during which epileptic fits occurred when the foetus was a male, but were absent when it was a female.

Labour itself may coincide with the onset

of epileptic convulsions, which may continue thereafter with a varying frequency for many years. Turner¹ described 5 cases of this type and mentioned 17 in which delivery caused a relapse in apparently cured cases after a normal pregnancy. Hayden²⁵ recorded a multiparous epileptic who always had her most severe convulsions during the birth of each child.

The puerperal and lactational periods are also sometimes responsible for the onset of fits and for the relapse of an apparently cured case. Gowers²⁰ and Struthers²¹ reported cases of puerperal epilepsy, and Turner¹ mentioned one in which fits began during lactation, ceased on weaning and only recurred during 3 successive lactational periods. Stander¹⁰ considers that lactation may increase the frequency of attacks, whilst Greenhill¹² doubts if this is so and is of the opinion that the aggravation of epilepsy by suckling is merely a medical myth.

CASE REPORTS.

At the West Middlesex Hospital during the 7 years 1939-45 inclusive, there have occurred 21 deliveries in 18 epileptic mothers. Records of 19 of these pregnancies in 16 patients have been available for analysis and are presented in Table II, from which the following conclusions can be drawn.

Family history. It is remarkable that in only 1 case (Case 10) was there a family history of epilepsy. Apart from actual convulsions evidence of mental instability or defect could not be obtained in the patients' parents or siblings. None of the babies showed any evidence of inheriting the taint. The significance of these findings will be discussed later, when the problem of heredity is reviewed.

Age of onset of fits. It will be seen that

TABLE II.
An analysis of 19 Pregnancies and Deliveries
in 16 epileptics.

Case No.	Age	Date of delivery	Family history of epilepsy	Age at Menarche	Age of onset of fits	Nature of fits	Total number of pregnancies	Intensity of fits during Pregnancy
1.	42	Jan. 1939	—	14	14	Improved after marriage	4	Unaffected
2.	30	July 1939	—	16	26	—	1	Unaffected
3.	32	July 1939	—	15	Not known	Menstrual	4	Unaffected
4.	38	Oct. 1939	—	12	Not known	Nocturnal	5	Worse
5.	28	Apr. 1940	—	14	24	Nocturnal	2	Worse
6.	37	Oct. 1941	—	14	7	—	1	Improved
	(24	June 1942)						
7.	26	Feb. 1944	—	11	20	—	3	Unaffected
	(27	Nov. 1945)						
8.	22	Oct. 1942	—	13	2	<i>Petit mal</i>	1	Unaffected
9.	28	Dec. 1942	—	14	14	Menstrual	2	Worse
10.	32	Aug. 1943	Mother has fits	13	13	Menstrual	5	Worse
11.	24	Sept. 1943	—	11	24	Gestational	3	Worse
	(38	Mar. 1944	—	17	37	Began in previous pregnancy	11	Worse
12.	(40	Aug. 1945	—	17	15	Menstrual	2	Unaffected
13.	41	Aug. 1944	—	17	15	Menstrual	2	Worse
14.	39	Sept. 1944	Not known	Not known	32	—	6	Unaffected
15.	40	Aug. 1945	—	14	26	—	4	Worse
16.	29	Nov. 1945	—	12	19	Nocturnal	1	Unaffected

in only 4 of the 16 cases did the fits commence during the "dangerous epoch" between 11 and 15 years of age, although in 3 cases they began in the same year as menstruation, 2 of these being menstrual in type.

Menstrual epilepsy. Four cases of menstrual epilepsy were encountered, of which 3 became worse during pregnancy and 1 remained unaffected, thus differing markedly from Baptisti's 7 quoted cases.

Gestational epilepsy. The table contains 2 cases of gestational epilepsy, 1 which began in the pregnancy under review (Case 11), and 1 which began in a previous pregnancy (Case 12). In both cases the fits have so far continued since delivery and are not associated with menstruation.

Behaviour of fits during pregnancy. If the cases of gestational epilepsy be included, it will be seen that 8 cases became worse during pregnancy, 1 was improved

vidence of eclamptic toxaemia	No. of fits during period of toxaemia	Labour and puerperium	Sex of child	Born alive or dead	Birth weight	Method of feeding
Generalized edema	1	Normal	Male	Alive	7 lb. 8 oz.	Breast—4-hourly
P. 170/100	—	Normal	Male	Alive	6 lb. 7 oz.	Breast—3-hourly
None	—	Normal	Female	Alive	5 lb. 13 oz.	Breast—3-hourly complemented
None	—	P.P.H.	Male	Alive	8 lb. 11 oz.	Breast—4-hourly
None	—	Normal	Female	Alive	7 lb. 9 oz.	Breast—4-hourly
None	—	Normal	Female	Alive	6 lb. 1 oz.	Artificial
None	—	Normal	Female	Dead	7 lb. 7 oz.	—
edema of legs albuminuria	2	Normal	Male	Alive	7 lb. 14 oz.	Breast—4-hourly
P. 146/90	1	Normal	Male	Alive	6 lb. 11 oz.	Breast—4-hourly
oedema	—	Normal	Female	Alive	6 lb. 8 oz.	Artificial
P. 145/90	—	Normal	Female	Alive	5 lb. 10 oz.	Breast—3-hourly complemented
None	—	Normal	Female	Alive	5 lb. 10 oz.	Breast—4-hourly
None	—	Normal	Male	Alive	8 lb. 2 oz.	Breast—4-hourly
Generalized edema	Many	Normal	Male	Alive	7 lb. 0 oz.	Breast—4-hourly
P. 140/90	Many	Normal	Male	Alive	7 lb. 14 oz.	Breast—4-hourly
Generalized edema	—	Normal	Female	Alive	7 lb. 10 oz.	Breast—4-hourly
None	—	Normal	Male	Alive	8 lb. 0 oz.	Breast—4-hourly
None	—	Normal	Female	Alive	6 lb. 4 oz.	Artificial
None	—	Normal	Female	Alive	6 lb. 4 oz.	Artificial
P. 170/200	Many	Normal	Male	Alive	6 lb. 3 oz.	Breast—4-hourly
100/120	—	Normal	Male	Alive	7 lb. 7 oz.	Artificial
Generalized edema	—	Normal	Male	Alive	7 lb. 7 oz.	Artificial
None	—	Normal	Male	Alive	7 lb. 7 oz.	Artificial

and 10 were unaffected. Reference to Table I will reveal that these figures do not agree even approximately with those of any previous observer. In the adversely affected cases, no association with quickening was noted.

There are 2 cases of repeated pregnancies. In case 7 (3 pregnancies) the fits were unaffected at any time by the gestation; in case 12 (2 reported pregnancies) the fits had begun in the 9th pregnancy, were intensi-

fied in the 10th, and unaffected in the 11th.

Seasonal influence. The time of the year of the pregnancy and labour bears no relation to the behaviour of the fits.

Influence of pre-eclamptic toxaemia. The presence or absence of pre-eclamptic toxaemia, as revealed by the existence of oedema, basic blood-pressure above 130/70 mm. Hg. or albuminuria, was noted in each case. In 6 cases one or more

of these signs was present, and in 13 they were all absent. Of the 6 toxæmic cases the fits in 3 became worse during pregnancy and in 3 they were unaffected, although in these latter cases 1 or 2 fits occurred during the actual period of the toxæmia, even though they had been absent for months previously; of the 13 non-toxæmic cases 5 became worse, 1 improved and 7 were unaffected. The significance of these findings will be discussed later.

The effect of epilepsy on the pregnancy. Premature interruption of pregnancy did not occur in this series. In the first pregnancy of Case 7, the patient fell during a fit 4 days before delivery at term, after which she did not feel foetal movements and foetal heart sounds could not be heard on admission to hospital. Labour ensued uneventfully with the foetus in the left occipito-anterior position, but a macerated stillbirth resulted. The placenta appeared to be normal in structure and attachment.

Labour and puerperium. Apart from Case 4 in which there was a postpartum hæmorrhage of 35 ounces, the labour and puerperium were normal in each case. Fits did not occur during labour, and none began during the puerperium.

The baby. No premature baby was born in these cases, and all the infants were alive and healthy, with the one exception already mentioned (Case 7). Ten of the babies were males and 9 were females. Of the pregnancies with male foetuses, in 4 the fits were increased in number, and in 6 they were unaffected; in association with females 4 were worse, 1 was improved and 4 were unaffected. In the 2 cases of repeated pregnancies, in the first (Case 7) the foetal sex had no effect on the frequency of the fits as they were equally unaffected whether the foetus was male or female, and in the second (Case 12) the fits had begun in the previous pregnancy (the 9th) with male twins, were worse in the 10th with a female

foetus, and unaffected in the 11th with a male. It is apparent that no relationship between the incidence of fits and the foetal sex can be discerned in this series of cases.

Breast feeding. There is no doubt that epileptic fits in the mother constitute a contra-indication to breast-feeding for fear of damage to the baby. In these cases we have been guided by social conditions. If a third capable person can always be present at feeding times we have permitted the baby to be put to the breast; when this is impossible artificial feeding has been substituted. It will be seen that breast-feeding was allowed in 14 of the 18 cases. It was found however that breast-fed babies tended to be sleepy if the mother were being given a sedative mixture containing bromides.

In none of the mothers was the epilepsy aggravated by lactation, thus corroborating Greenhill's opinion that the danger of lactation has been exaggerated. Epilepsy beginning during lactation has not been encountered here, although observations have been of necessity restricted to the first 2 months after delivery whilst the patient has still been attending the post-natal clinic.

THE CAUSE OF THE CONVULSION DURING PREGNANCY.

Since the mode of production of the idiopathic convulsion in the non-pregnant patient is unknown, we are obviously doomed to failure if we attempt to portray its mode of production in the pregnant, parturient or lactating patient. Yet to understand this matter fully we have to probe it to even greater depths than this, for we have to describe the mechanism whereby in some cases the frequency of fits increases during pregnancy, in others it diminishes, whilst in others it remains

unaffected. Any explanation we can offer must thus be an extremely labile one, and must encompass either of two changes in opposite directions, or else no change at all. Let us examine this problem in the shadow of these difficulties and attempt to find what factors induce or relieve fits in a confirmed epileptic, and see if the state of pregnancy in any way intensifies or annuls these mechanisms.

In such an attempt to correlate the state of being an epileptic with the state of being pregnant, a facile solution dependent on such factors as the age of the patient, the season of the year or the sex of the child will not be found. Data in Table II effectively dispose of a simple solution along these lines. The most likely clue here is the co-existence of pre-eclamptic toxæmia, which we will show later has a bearing on the occurrence of convulsions.

A step towards the solution of this problem has been taken since a deeper insight into the mechanism of epilepsy has been achieved through the medium of the electroencephalograph. This has shown that epileptic subjects have a distinctive pattern of cerebral waves called by Lennox, to whom we are most indebted for this knowledge, "cerebral dysrhythmia." He and his colleagues have shown²⁶ that cerebral dysrhythmia is present in all patients during the time of the epileptic seizure, and is also present in 90 per cent of epileptics between the seizures; they found it to be present in approximately 10 per cent of normal persons. Dysrhythmia is not peculiar to epilepsy but is present also in an undue proportion of individuals whose psychical processes are abnormal. Its presence is a familial trait, for if the relatives of an epileptic are subjected to electroencephalography it is found that about 60 per cent of them will show dysrhythmia. Lennox *et al.* investigated the parents of 88 epileptic families and found

91 per cent of them to be affected. It is evident then that individuals who have this dysrhythmia are potential epileptics, and that the presence of some exciting factor is required to give rise to an actual convulsion. Menstruation and pregnancy might well be such a factor. Gestational epilepsy would then be regarded as the culminating event when the strain of pregnancy is imposed on a susceptible, dysrhythmic individual.

Bachmann³ in discussing this point states rather aptly that pregnancy is not in itself a cause but acts rather as a catalyst in producing fits in a susceptible person. This conception is illustrated by a case of symptomatic epilepsy described by Westphal,²⁷ in which the patient was known to have a cortical cyst; when she became pregnant the fits increased in intensity and frequency, through the catalytic action of the pregnancy. When the cyst was removed the fits ceased and the pregnancy continued uninterrupted. In a similar manner the action of convulsant drugs²⁸ such as camphor compounds and creatin when applied to the cortex is well known. Under the catalysing influence of pregnancy the experimental animal becomes increasingly susceptible to the irritant effect of these drugs, and the fits are more readily induced by smaller dosages.

Bearing these facts in mind, let us consider in what manner the physiological changes accompanying pregnancy can intensify the process of epileptogenesis and cause an increase in the number of fits. With the exception of cases of gestational epilepsy, the patient will probably know of her affliction, and will be receiving treatment prior to pregnancy. The dose of her depressant will have been adjusted to reduce and keep the fits to a minimum. When she becomes pregnant she may suffer from vomiting or altered gastric acidity, in which case the dose of sedative taken and

absorbed may be reduced. Moreover her weight will increase, partly due to the products of conception and partly due to water retention; the effective dose of her sedative will now not exert the same controlling influence and her epilepsy will become worsened—apparently by the pregnancy. If bromides are being used as a depressant their efficacy will be impaired by the pregnancy, for as there is a retention of Cl ions in the tissues at this time,²⁹ the Br ions will be displaced, and their sedative action will be rendered less effective. These circumstances, however, can only play a minor rôle, for in such cases increased dosages would restore the patient to her level of normality, whereas in actual fact, it is usually found that she becomes worse in spite of an increased dosage of drugs.

Apart altogether from the question of drugs, water retention itself may have a further important influence, for it is well known to be conducive to fits, presumably through the medium of cerebral oedema. Thus the performance of encephalography in confirmed epileptics² has shown abnormal meningeal spaces over the frontal and parietal areas of the brain with dilated ventricles—a picture in brief of chronic waterlogging. Experimentally, Rowntree³⁰ produced fits by injecting large quantities of water into dogs. It is equally conceivable that the water retention of pregnancy might serve to increase the fits in a susceptible individual. The water-pitressin test performed in non-pregnant epileptic subjects, as described by many workers, is not without interest here. Blyth³¹ gave his patients water to drink over a period of 48 hours until their body weight was increased by 2 per cent. They were then given 300 c.cm. of water and $\frac{1}{2}$ c.cm. pitressin every 2 hours for 10 doses, and 45 fits were thereby induced in 49 suspect epileptics, of whom 39 (86.6 per cent) were verified later. Garland *et al.*³² using a

similar technique increased the body weight by 3.5 per cent and then found that injections of pitressin produced fits in 17 of 44 epileptics (39 per cent), in 12 of 32 doubtful cases (38 per cent), and in none of 20 controls. It is tempting to conclude that the state of pregnancy parallels this test, for although there is no proved increased secretion of pitressin at this time, the water retention causes an increase in body weight of over 3.5 per cent, so that the epileptogenetic mechanism may become operative. It is interesting to note that on averaging the results of many performances of this test, fits were induced in about one third of the total number of epileptics investigated—approximately the same proportion of epileptics that become worse during pregnancy. Possibly menstrual epilepsy can also be correlated with the water retention that is known to occur before and during the time of the menstrual period.

It has been shown that brain activity is dependent on the CO₂ tension in the blood.³³ Thus if dysrhythmia is produced in electroencephalographic tracings by anoxaemia, the addition of CO₂ will immediately restore the rhythm to normal. Moreover, deprivation of CO₂ will induce fits in epileptics; thus Janz³⁴ was able to produce fits in 10 per cent of epileptics by hyperventilation with subsequent lowering of the CO₂ tension in the alveolar air and blood. Venepuncture of the internal jugular has shown that the cerebral blood in patients subject to *petit mal* contains less CO₂ than in normal subjects. Now in pregnancy Porges and Novak³⁵ have shown that the CO₂ tension is reduced in the alveolar air, whilst the alkali reserve of the blood is reduced from 65 vol. per cent to 45 vol. per cent at term. This reduction in CO₂ may well be an exciting factor in causing an increase in the number of fits during pregnancy. A true alkalosis is known to be another aggravat-

ing factor in epilepsy, but this cannot play a part during pregnancy as the pH of the blood remains remarkably constant at 7.40.

Tauberhaus and Engle¹⁶ have demonstrated that idiopathic epilepsy is sometimes associated with hypocalcaemia. Although the blood and cerebro-spinal calcium of epileptics are within normal range, a slight diminution may act as a trigger which fires off a convulsion. Now in pregnancy there tends to be a slight lowering of the level of calcium in the blood to an average of 9.5 mg. per 100 c.cm. at term.³⁷ This again may well be a worsening factor when pregnancy occurs in an epileptic subject.

Lastly, we must mention hormonal causes. Little can be said about them at present because the influence of the sex hormones on fits has not been adequately investigated, but the possible effect of their increased concentrations before menstruation and during pregnancy, as well as the reputed link between fits and the foetal sex, must be borne in mind.

Thus there are many channels through which the adverse strain of pregnancy may affect the susceptible individual—through water retention, CO₂ deficiency, hypocalcaemia and possibly altered hormonal relationships.

Let us now consider the opposite picture and see if there are any happenings in pregnancy which would tend to mitigate the severity of the convulsions. Bachmann⁷ suggests that improvement may occur in pregnant women who were previously subject to menstrual epilepsy because the causal factors are no longer present when amenorrhoea of pregnancy exists. However he gives no explanation of the mechanism whereby this improvement is effected. A decreased number of fits is known to result in confirmed epileptics from the development of acidosis.² Thus fasting and a ketogenic diet both reduce

the number of fits in epileptics, and have indeed been employed as therapeutic measures. It is possible therefore that excessive vomiting occurring in pregnancy may induce a state of ketosis which exerts a beneficial effect on the disease. It might be argued that as the ketosis is only of short duration it cannot lessen the fits throughout the whole course of pregnancy; this however is not necessarily so, for it is known that in epileptics any event which reduces the fits may have a prolonged beneficial effect. Thus scarlet fever, measles and varicella have all caused a cessation of fits long after the period of infection is over, whilst Gowers²⁰ reported a case of typhoid fever occurring in an epileptic boy after which fits remained absent for 20 years. Garrod³⁸ described an epileptic patient in whom the fits were permanently cured by an attack of gout. In a similar manner it is reasonable to conclude that ketosis occurring in early pregnancy may reduce the number of fits throughout its whole duration.

One other observation deserves mention. Altenburger and Stern³⁹ found that there is an underfunctioning of the posterior lobe of the pituitary gland in epileptics which may play a part in causing fits; the guinea-pig uterus suspended in epileptic serum does not undergo rhythmic contractions as it does in the serum of healthy controls. Possible alterations in the posterior pituitary during pregnancy might eliminate this causal process so that the patient shows some improvement.

Study of the pregnant epileptic patient would be incomplete without consideration of electroencephalographic tracings taken during pregnancy. These do not appear as yet to have been investigated in the epileptic subject, but Gibbs and Reid⁴⁰ have taken tracings during normal pregnancy. They found that only 60 per cent of 20 pregnant women had a normal rhythm, compared

with 85 per cent of 100 normal non-pregnant controls. These figures are too small to base conclusions on, but they do suggest that pregnancy itself has not a beneficial effect on cortical activity, and that it would therefore tend to encourage rather than inhibit the occurrence of fits.

Summing this matter up, what are we to make of it? Probably all the factors mentioned play a rôle at some time in the genesis of fits; according to the different clinical course of each pregnancy, so will the water retention, the CO₂ deficiency, the hypocalcaemia or the ketosis play a dominant part, and so accordingly will the fits become worse, better, or remain unaltered. The alternating behaviour of the same patient in successive pregnancies will be explained by the different clinical picture which characterises each pregnancy, and which may, by coincidence, correspond with a particular sex of the foetus. When an epileptic becomes pregnant, therefore, the course of her epilepsy will be dependent upon the course of her pregnancy, and the number of fits will result from the summation of related and antagonistic factors exercised on the nervous system of a susceptible and dysrhythmic individual.

THE RELATION OF EPILEPSY TO ECLAMPSIA.

In view of the identical nature of the convulsion in epilepsy and eclampsia, it is not surprising that a relationship between the two diseases should have been postulated; if the convulsion is the same, may not the cause be so? At the close of the last century, Féré¹¹ suggested that eclampsia was an acute form of epilepsy, whilst Poter¹² considered them to be identical diseases. Zangemeister¹³ partially inclined towards this view, stating that 2 per cent of eclamptics were left with residual epilepsy, and Féré agreed that epilepsy might be inaugurated by an attack of eclampsia. Cases have

been reported which lend support to this hypothesis; thus Whapham and Hogg¹⁴ described a patient who was delivered following a medical induction for severe pre-eclampsia, and who was discharged home on her 14th day, free from all signs of the disease. On the 17th day postpartum she had a typical convulsion. Rosenbaum and Maltby¹⁵ recorded a case of persistent *petit mal* following eclampsia, and others have been quoted by Dexter and Weiss¹⁶ and DeLee.¹⁷

A further connection between the two diseases is evident from the fact that a large proportion of the relatives of eclamptics are subject to convulsions, thus showing a constitutional predisposition to fits in these cases. Rosenbaum and Maltby¹⁵ studied a series of 20 eclamptics and found that 12 gave a family history of convulsions—8 had relatives who were subject to epilepsy and 4 who had had eclampsia. A control series of 20 non-convulsive pre-eclamptics yielded only 2 cases with similar family histories. Though these cases are few in number, there is at least the likelihood that eclampsia occurs more readily in patients with a constitutional predisposition to convulsions.

One further point of interest is that eclampsia is known to occur more readily in some patients than in others. In 1893 Dührssen¹⁸ stated that eclampsia occurred in two forms, *eclampsia reflectoria* characterized by cerebral instability and little evidence of liver or kidney disease, and *eclampsia toxica* distinguished by marked toxic changes in these organs. More recently Browne²² has pointed out that with identical degrees of albuminuria, elevation of blood-pressure and other signs of toxæmia, one patient will go into eclamptic convulsions whilst another will not. It seems, therefore, that a varying degree of nervous instability exists which plays a part in causing the eclamptic fit.

Thus we are presented with 3 phenomena which call for correlation:

1. The occasional inauguration of epilepsy by an attack of eclampsia.
2. A predisposition to fits in the relatives of eclamptics.
3. The unequal tendency to fits in pre-eclamptics of equal severity.

The correlating factor in question appears to be the existence, in varying degrees in different patients, of the basic nervous instability which is revealed in electroencephalographic tracings as cerebral dysrhythmia. Epileptics and their relatives are not alone in being subject to this abnormality, for eclamptic patients are similarly afflicted, although not to the same extent. Thus Rosenbaum and Maltby⁴⁵ demonstrated the presence of dysrhythmia in 13 out of the 20 eclamptics (65 per cent) already quoted, as against only 2 of the 20 (10 per cent) non-convulsive pre-eclamptic controls. It is thus probable that when pre-eclamptic toxæmia supervenes in a patient with dysrhythmia it gives rise to eclampsia reflectoria, and in a patient free from this abnormality to eclampsia toxica. Similarly, when a patient has a certain degree of toxæmia, fits will supervene sooner if she has dysrhythmia than if she possesses a normal cerebral pattern. Again, as dysrhythmia is a familial trait, the incidence of fits—either epileptic or eclamptic—will be greater in the relatives of eclamptics than in normal subjects.

It is thus evident that the dysrhythmia is the connecting link between the two diseases, which is activated in each malady by an appropriate trigger mechanism to produce the convulsion. In eclampsia the cerebral vaso-constriction with or without oedema, culminating in cerebral anaemia, serves to fire off a convulsion, whilst in epilepsy the exciting mechanism is associa-

ted with cerebral oedema, hypocalcaemia, CO₂ deficiency or alkalosis.

Rosenbaum and Maltby conclude from their studies that the cerebral dysrhythmia is identical in these two conditions and that any person predisposed to fits (as revealed by dysrhythmia or by a family or personal history of convulsive disorders) is likely to exhibit them in the presence of pre-eclamptic toxæmia. Such cases they consider would not be true eclampsia, but rather "epileptic convulsions associated with toxæmia." This conclusion is borne out by the present study, provided the toxæmic cases develop some degree of cerebral oedema, for it is when generalized oedema occurs that the fits are produced. Thus of the 6 toxæmic cases portrayed, 3 had an increased number of epileptic fits during pregnancy, and although the remaining 3 were unaffected throughout pregnancy as a whole, they each had fits during the period of the toxæmia. The occurrence of these fits was found clinically to be associated with the onset of generalized oedema and was unrelated to the development of hypertension.

It is true that 5 of the 13 non-toxæmic cases became worse in the absence of generalized oedema; presumably one of the other suggested trigger mechanisms was the responsible factor in these cases.

In each disease then, there exists a common basic instability which is reacted upon by an exciting factor to produce a fit. The problem of the actual cause of the fit may not be resolved by such a simple equation as "basic instability *plus* exciting factor produces a convulsion" as Rosenbaum and Maltby suggest. It is true so long as oedema is the exciting factor, but otherwise the basic instability of each disease requires its own special trigger mechanisms to produce fits. Thus the epileptic instability is not influenced by physical stimulation or by high blood-

pressure, which are the eclamptic trigger mechanisms, to give rise to fits; similarly eclamptic instability is not influenced by the epileptic excitants to produce true eclampsia, for this did not supervene in any of the 6 toxaemic cases, which all tended on the contrary to run a mild course. The one factor which can play the dual rôle of excitant in both diseases is a generalized oedema particularly affecting the central nervous system; apart from this, the exciting factors are not interchangeable.

If fits were to supervene in the presence of severe pre-eclampsia it would be difficult to decide whether they were epileptic fits in a pre-eclamptic or eclamptic fits in an epileptic; in such a borderline case there would be real confusion, and status epilepticus in a toxaemic patient would closely simulate true eclampsia in an epileptic. We can draw the practical conclusion from these facts that toxaemia occurring in an epileptic subject calls for strict and early treatment, and measures must be directed particularly towards preventing the onset, or reducing the extent, of a generalized oedema.

STATUS EPILEPTICUS.

The occurrence of status epilepticus is a complication always to be most dreaded. It may supervene during pregnancy, labour (Turner¹), or the puerperium (Struthers²¹); it may be preceded by worsening of the fits, or it may be the start of the whole epileptic process (Turner¹). Sachs⁷ reported 2 cases occurring in sisters, in both of whom it proved fatal. This result is the usual one met with when status epilepticus supervenes during pregnancy or labour; this fact has been emphasized by DeLee,¹⁷ and Greenhill,¹² and Sachs went so far as to state that a fatal termination was inevitable. The only hope of saving the

patient lies in terminating the pregnancy, and yet when this was done by manual dilatation of the os (Jardine¹⁹), or by manual dilatation and packing the uterus (Sachs⁷), the result was still a fatality. Nerlinger,¹³ Neu²⁰ and Zweifel²¹ all agreed that death nearly always occurred in spite of termination of the pregnancy. Termination was, however, recommended by Bachmann,³ who stated that an immediate improvement sets in following the operation. It would appear on a *priori* reasoning that since the pregnancy itself, or one of its associated factors, is responsible for the development of the status, termination is logically indicated, provided this can be done in a manner calculated not to cause trauma or shock in a patient already seriously ill and in coma. As early observers found to their cost, accouchement forcé plays no more part in the treatment of pregnancy and the status epilepticus than it does in the treatment of the status eclampticus. With these considerations in mind, termination was carried out in a case of status epilepticus at the West Middlesex County Hospital, as will now be described.

CASE REPORT.

Mrs. V. I., a primigravida, aged 34, attended the antenatal clinic on October 5th, 1945, when she was 3 months pregnant.

Personal history. She had scarlet fever at the age of 10 years without residual nephritis. The menarche also occurred at 10, cycle 7/21, regular and painless. At 16 years of age fits in the form of *grand mal* had begun. There was no family history of epilepsy. The fits were induced by menstruation, over-eating, constipation, excitement and depression. Their frequency was kept in check by luminal, but even large doses did not inhibit those occurring during menstruation. She was married when aged 24 years, and the fits then became worse; they occurred 4 times per week, were induced by sexual intercourse and were relatively unaffected by drugs.

History of pregnancy After 10 years of married

life, during which contraceptives were used, she became pregnant, and expected to be delivered on April 8th, 1946. During pregnancy the fits became worse in spite of increased dosages of drugs, sometimes occurring every night. When first seen at the antenatal clinic she was found to be 14 weeks pregnant, she had had no vomiting, but occasional headaches. All systems were normal on examination, and the Wassermann reaction was negative. Her blood-pressure was 120/74 mm. Hg. and her urine was normal.

Apart from the fits the pregnancy progressed normally until the 28th week, when on December 25th, 1945, she bled vaginally for 1 hour. She reported this at her next visit to the clinic on January 1st, 1946, and was admitted forthwith. She had slight oedema of the ankles at this time, but this rapidly cleared with rest in bed, and her blood-pressure never exceeded 128/84 mm. Hg. She did not have fits during January, and further bleeding did not occur; blood group A; Hb. 76 per cent; and on inspection the cervix appeared healthy. She was kept on luminal gr. i nocte.

On February 4th, when 33 weeks pregnant, she became restless in her sleep and potassium bromide gr. 20 was given thrice daily in addition to the luminal. Slight oedema was now noticed in her ankles and hands; blood-pressure 110/70; urine normal.

On February 5th 2 major epileptic fits occurred. Blood-pressure 115/80. The luminal was increased to gr. 1½ t.d.s. and epanutin gr. 1½ t.d.s. was also given.

At 1.10 a.m. on February 6th she lapsed into status epilepticus and had 12 fits before 4.15 a.m., being unconscious and incontinent between them. She was given soluble luminal gr. 3 intravenously, and 16 c.cm. of paraldehyde intramuscularly, which produced a temporary cessation of the convulsions. She was then unconscious, with a pulse-rate of 140, a respiratory rate of 40, and a blood-pressure of 105/60. During the afternoon 8 further fits occurred, but ceased following pentothal 0.5 g. given intravenously, and the withdrawal of 30 c.cm. of cerebro-spinal fluid by lumbar puncture. This fluid was under the pressure of 10 to 11 cm. of water and was clear, containing 2 lymphocytes per c.mm., glucose 100 mg., chlorides 760 mg., total proteins 40 mg., without increase in globulins, per 100 c.cm. Her condition was then slightly

improved, temperature 100°F., pulse 130, respirations 30. The condition of the foetus appeared satisfactory, the heart rate was constant at 150, and it presented by the vertex in the right occipito-lateral position.

The fits were now kept under control by pentothal 0.5 g. 12-hourly, supplemented with potassium bromide gr. 20 and luminal gr. ½, 4-hourly, and epanutin gr. 1½ 6-hourly. She remained unconscious and incontinent, but was able to swallow glucose drinks.

At 2 p.m. on February 7th it was decided to terminate the pregnancy by low rupture of the membranes. Accordingly, under pentothal 0.45 g. the membranes were stripped from the lower uterine segment and then ruptured.

History of labour. On February 8th the patient appeared improved, regaining consciousness but speaking with difficulty. Temperature 100.2°F., pulse-rate 104, respirations 28, and blood-pressure 120/70. Urine contained sugar and a trace of acetone. The slight oedema still persisted. Uterine contractions were present and labour was judged to have begun, but she did not complain of pains.

She remained in this condition throughout February 9th, during which day she had 7 fits, On February 10th she relapsed into unconsciousness and had her worst day—119 fits occurred in all, 67 of them being severe convulsions. By the evening her temperature, pulse-rate and respirations had risen to 103.8°F., 120, and 38 respectively; blood-pressure was 120/70 and she had developed oedema of the lungs. She was given a total of 1.75 g. pentothal and gr. ½ nembital intravenously during the day, in addition to the potassium bromide, chloral, luminal and epanutin.

On February 11th the fits continued, and uterine contractions were felt to be stronger. Vaginal examination at 10 a.m. revealed the os to be fully dilated, with the vertex presenting. A forceps extraction was performed under pentothal 0.45 g. at 10.30 a.m., and a living male child, weighing 3 pounds 14 ounces, was extracted following episiotomy. The placenta, which appeared quite normal, followed 10 minutes later with the loss of 7 ounces of blood.

History of puerperium. Throughout the day of delivery she remained very ill, and had 6 more fits. On the following day she had 3 fits, but these

were the last, making a total number of convulsions of 163. Thereafter she improved slowly but steadily. She regained consciousness on this day, but was drowsy and talked slowly until February 18th. Her sedatives were discontinued except for luminal gr. i., t.d.s. The oedema was noticeably less on February 14th, and was completely gone by February 18th.

She had, however, some further trials to undergo. For the first few days after delivery she had marked pulmonary oedema, temperature 104°F., pulse-rate 120, respirations 40. This was considered to be due to bronchopneumonia, although physical signs of consolidation were not detected in the lungs. Her condition rapidly improved with sulphathiazole 24 g. and 600,000 units of penicillin given over 5 days.

Obstetrically the puerperium was normal until on February 27th she developed a *Bact. coli* urinary infection. A course of sulphathiazole was recommenced on March 1st, when she showed a marked sulphonamide-sensitivity reaction, her temperature rising to 105°F., and her skin developing a generalized maculo-popular rash. These quickly subsided when the sulphathiazole was stopped.

The baby. The baby was asphyxiated at birth, but responded to treatment. It lived only for 9½ hours, and during this time it had twitches and convulsions. At post-mortem examination a tear at the anterior end of the straight sinus was found with extensive haemorrhage between the hemispheres above the corpus callosum, on the tentorium, beneath the cerebellum and in the foramen magnum.

Post-natal examinations. Prior to discharge on March 18th, the patient was quite free from fits and was taking luminal gr. i, b.d. Blood-pressure 128/72, urine normal, there was no oedema, and her breasts and genitalia had involuted well.

When seen 1 month later she was still in good health and had not had further fits; 2 months afterwards the fits were recurring with their normal pre-gestational frequency.

DISCUSSION.

There are many features of interest in this case. From the age of 16 the patient had epilepsy of the menstrual type, the

onset of which had post-dated the menarche by 6 years. Following marriage it had worsened, and this tendency had been aggravated by the pregnancy. During her month's rest in Hospital—necessitated by ante-partum haemorrhage for which a cause could not be determined—the fits ceased, and yet following the appearance of oedema in the hands and feet (unaccompanied by other evidence of pre-eclamptic toxæmia) the fits recurred and status epilepticus supervened quite rapidly.

There is no doubt that the termination of the pregnancy was responsible for saving the life of this patient. As the status followed upon the appearance of the oedema, it is probable that the diminution of oedema after delivery was the mechanism whereby the improvement was effected; it is true that oedema persisted for some days after the fits had ceased, but during this time it was steadily decreasing. After the inception of the status the patient was never at any time fit for Caesarean section or any major operative procedure; separation and low rupture of the membranes were judged to be the correct treatment in her case. It was unfortunate that 4 days elapsed before true labour pains started; during this time she must have prejudiced her chances of recovery by having 131 convulsions, which reduced her condition to the grave and almost moribund state which it reached just before delivery. Of all the sedatives employed, intravenous pentothal was the most efficacious. The treatment to be recommended for status epilepticus during pregnancy would therefore appear to be:

1. Surgical induction of labour by a non-shocking technique, such as separation and low rupture of the membranes.

2. Control of fits by pentothal and other sedatives, combined with judicious use of lumbar puncture, until delivery is accomplished and the fits have lessened or ceased.

3. Maintenance of cardiac strength by glucose fluids, oxygen, cardiac stimulants and skilled nursing.

4. Ready recourse to sulphonamides and penicillin to eliminate septic processes, such as bronchopneumonia, which are very liable to follow a period of coma and multiple fits.

With the recent popularisation of curare, the question of its use in the treatment of status epilepticus becomes of great interest. Theoretically through its mode of action by inhibiting the effect of acetylcholine on the myoneural junction it would seem to be the drug most likely to bring the convulsions under control. Bennett³² described the use of curare in one case of status epilepticus (not associated with pregnancy) in which the seizures had been uncontrolled by sedatives and ether anaesthesia for 10 days; with continuous intravenous curare the patient was completely relaxed and free of seizures. Unfortunately death occurred from heart failure. It is possible that curare may be destined for a prominent rôle in the future treatment of status epilepticus, and its use should certainly be contemplated if the fits cannot be brought under control by other means.

STERILIZATION.

Bachmann³ considered that any pregnant patient who developed status epilepticus and recovered should subsequently be sterilized. He offered no evidence in support of this contention, and in view of the rarity of recovery it is not surprising that records of subsequent pregnancies after status epilepticus cannot be discovered. We do know that what happens during one pregnancy in an epileptic is no guide to what will happen in a subsequent pregnancy. However, the risk of a second visitation of the status is one which no patient should be allowed to run, and in these

cases sterilization is certainly justified. In the case described this operation has been done.

Bachmann also advocated sterilization on eugenic grounds in other types of cases, for example, in all serious cases of epilepsy, cases of psychological disturbance and cases of cerebral degeneration. Greenhill¹² recommended sterilization in any epileptic patient whose condition was aggravated by pregnancy. Williams³³ advised it if the mentality progressively deteriorated with each succeeding pregnancy. Here these observers are on much less secure ground, and postulate controversial matter which does not concern us primarily as obstetricians. Even a severe case of epilepsy may undergo improvement during pregnancy, and if aggravated during one pregnancy it may be improved during the next, so that interference cannot be automatically warranted. Should the fits become worse during pregnancy, can we terminate and sterilize in anticipation of status epilepticus, as advocated by Binswanger⁵ and Nerlinger?¹³ It is doubtful if even this is justifiable for we have seen that although approximately one third of all epileptics become worse during pregnancy, the grand climax of status epilepticus supervenes very rarely, and would not warrant the sacrifice of these infants. It is claimed by Gibbs³⁴ that the occurrence of *grand mal* seizures can be predicted by accurate interpretation of electroencephalographic tracings. If an increased incidence of fits and the possible supervention of status epilepticus can be foretold in this way, a definite indication for interference would be presented, but patients subject to such electroencephalographic control must for a while remain very few. For the present, therefore, unless there are special indications advocated by the physician, sterilization must be restricted to those cases which have been rescued from status epilepticus.

HEREDITY.

There remains to be said one final word about the infants of these epileptic mothers. Are they worth saving? As might be expected this is again a controversial point. Echeverria⁵⁵ in 1880 published the case histories of 553 children of 136 epileptics, and showed that 35 per cent died of fits during childhood, 18 per cent were mentally defective and only 19 per cent were normal. Casavieilt and Bouchet⁵⁶ quoted 58 children of 14 epileptic mothers of whom 37 per cent "died young" and only 24 per cent were healthy. These are grave figures indeed, but more recent observers suggest that they are unnecessarily so, as they probably include cases of congenital syphilis and other organic diseases. In 1916 Thom⁵⁷ investigated 553 children of 138 epileptics and found that only 10 (1.8 per cent) were subject to fits; Pilcz⁵⁸ studied 161 children of 144 epileptics and found only 3 (1.9 per cent) were affected. The consensus of opinion at a British Medical Association meeting held in Victoria in 1927 was that the frequency and importance of heredity had been exaggerated; Baptisti¹¹ agreed with this, stating that transmission occurred less often than was commonly thought. Stander¹⁰ also found a family history of the disease in only 6 of 37 pregnant epileptics, whilst Myerson⁵⁹ investigated the relatives of 1,500 epileptics and found only 4 families to be affected, comprising 11 individuals in all. Russell Brain⁶⁰ summarises the problem by estimating that the risk of transmitting epilepsy is 1 in 10, and that in a family of 10 children the first is the one most likely to be affected. The absence of a family history of epilepsy in the cases presented from the West Middlesex County Hospital during the last 7 years certainly tends to confirm this latter view and probably the outlook for the child can be considered to be fairly good.

These opinions are supported by electroencephalographic studies which have shown that it is not manifest epilepsy which is inherited, but only the predisposition thereto, which is revealed by the presence of dysrhythmia. Lennox, Gibbs and Gibbs,⁶¹ studying 183 relatives of 94 patients with epilepsy, found that 60 per cent had dysrhythmia, although only 2.4 per cent suffered from fits. They found dysrhythmia more frequently in female relatives and in the relatives of female patients and concluded that females have more predisposition to idiopathic epilepsy than is the case with males. They calculated on the above figures that manifest epilepsy occurs in every 25th dysrhythmic patient, and that the disease is more likely to be inherited if both parents are subject to dysrhythmia. Hence if an epileptic wife wishes to know the calibre of her future progeny, we can reassure her that the chance of a normal child is good, especially if the electroencephalographic tracings of her husband show a normal pattern.

Thus the statistics of recent observers and the results of electrical tracings combine with clinical experience to suggest that the inheritance of epilepsy is an infrequent occurrence; we can conclude accordingly that eugenic grounds offer no real indication either for the termination of an established pregnancy or for sterilization.

SUMMARY.

1. The literature of epilepsy complicating pregnancy, labour, the puerperium and lactation is reviewed.

2. Nineteen cases of epilepsy occurring in 16 mothers from 1939 to 1945 at the West Middlesex County Hospital are presented and discussed.

3. Factors influencing the behaviour of fits during pregnancy are postulated, with

special reference to the relation between epilepsy and eclampsia.

4. A case of status epilepticus occurring during pregnancy is presented, and termination of pregnancy, which was successful in this case, is advocated as the treatment of choice.

5. The modern outlook on sterilization and the transmission of epilepsy is reviewed.

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Myasthenia Gravis and Pregnancy (A Case Report)

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IN a recent communication to this Journal, Wilson and Barr¹ drew attention to the fact that myasthenia gravis as a complication of pregnancy and the puerperium had received very little attention in the English medical literature. This fact becomes more significant in view of the improved prognosis for this disease since prostigmin became available in 1935. It would appear^{2, 3, 4} that obstetrical opinion is slowly but definitely changing in regard to the management of these cases, and further evidence of the essential "normality" of pregnancy and labour in the prostigmin-controlled patient may therefore be timely.

Whilst it is agreed⁵ that therapeutic abortion no longer has any place in the control of myasthenia gravis when complicated by pregnancy, there is less uniformity on the question of whether the patient should be allowed to deliver herself by the natural channels. "Of the few reported cases that have been delivered normally," wrote Wilson and Barr¹ in their extensive review of the literature, "the rapidity of labour and the absence of complications have been especially noted."

The case record to be submitted offers evidence in support of these observations.

CASE RECORD.

Mrs. M. B. was an intelligent country girl who previously had always enjoyed good health. She

was 25 years of age and recently married, when in June 1944 she began to notice weakness in her hands and legs. She experienced difficulty in manipulating small objects and suffered severe and frequent headaches. By March 1945 she was largely incapacitated; in her own words, "she felt useless." She was no longer able to carry out the simplest household duties, kitchen utensils were dropped and she felt constantly fatigued. Difficulty in swallowing had reached a stage where liquids regurgitated through the nose and semi-solid food only could be taken.

Breathing seemed to be a constant effort; the eyelids dropped, almost completely limiting her vision; she found that she could no longer smile, her face "seemed stiff." Talking became a great effort and her words would trail off and become indistinguishable. Sometimes when she tried to say something no sound would be produced. Her chin would drop on to her chest so frequently that she developed a troublesome ache across the back of her neck. Some of these symptoms could be temporarily relieved by rest, but the amelioration of symptoms seldom lasted for more than half an hour. There was, however, an appreciable variation in the severity of her condition from week to week and she particularly noticed an association with her menstrual cycle.

There was a definite remission of symptoms from approximately the 8th to the 23rd day of the intermenstrual period, followed by a relapse usually commencing about a week before the onset of menstruation and continuing throughout the period of the flow and for some days afterwards. Because of this association and because she realized that she was getting worse, the patient and

her husband developed the idea that pregnancy might be desirable as affording the means of securing a prolonged remission of the more severe symptoms. Contraception was therefore abandoned at this stage and menstruation ceased 3 months later; the last menstrual period commencing on 16th June, 1945. During these three months she had continued to lose weight; from 11 stone 5 lbs prior to her illness to 9 stone. She was constantly hungry, but because of her dysphagia was seldom able to satisfy her hunger. She found that she had become emotionally unstable and was inclined to cry on the slightest provocation.

During the first 3 months of her pregnancy there was an increase in the severity of most of her symptoms, but early in October 1945 she experienced a definite remission and found it possible, at last, to follow the advice of her doctor to seek specialist treatment in a capital city. This involved a two and a half days' journey, but accompanied by her husband, this was accomplished without incident. Treatment with prostigmin and ephedrine was commenced and the patient returned to the country where she entered a hospital in her home town. Because of the co-existent pregnancy however, she was transferred to the Brisbane General Hospital on 16th November, 1945, where I saw her in consultation shortly afterwards.

She presented a typical picture of myasthenia gravis with bilateral ptosis of the upper eyelids, slow deliberate movements and slurring of speech. She expressed the opinion that the weakness of her limbs and liability to fatigue was now less severe than formerly, but was concerned about her difficulty in swallowing. The uterus was enlarged to the size of a four and a half months' pregnancy. Treatment, which had been instituted immediately upon admission, consisted of the oral administration of 30 grains of prostigmin and $1\frac{1}{2}$ grains of ephedrine three times a day, together with a daily combined injection of prostigmin 0.5 and $1/100$ grain of atropine. A suitable diet was prescribed. Radiological examination of the superior mediastinum failed to reveal any abnormal shadows.

Subsequently, under this therapeutic régime steady progress was made towards improvement and the patient was admitted to the wards of the Brisbane Women's Hospital. The residual weakness in the limbs disappeared first but it was more

than three weeks before the patient was able to swallow without difficulty. Consciousness of respiratory effort disappeared about the same time. Ptosis of the eyelids was the last manifestation to be relieved. However, in spite of this general improvement there was a tendency to occasional relapses lasting for three to four days, and the observation was made that these relapses corresponded closely to the times of the suppressed menstrual periods. They were characterized by drowsiness and a return of ptosis of the lids, dysphagia and slurring speech.

By the time the pregnancy had advanced to the 8th month the patient was considered to be well enough to leave hospital temporarily to stay with relations in the city. Treatment with prostigmin and ephedrine in the previous dosage was continued, the patient administering the hypodermic injection herself. Occasionally, through forgetfulness, she omitted to take the ephedrine or prostigmin tablets and found that she always suffered a minor relapse under these circumstances. There was no complaint of sleeplessness or excitement with the use of ephedrine in the dosage given. After 37 weeks gestation she developed a severe "cold" which appeared to precipitate a relapse lasting for a week with return of dysphagia and some degree of ptosis.

She re-entered hospital and subsequently remained in good health, labour pains commencing on the morning of 28th March, 1946. Acting on a previous decision, a combined injection of prostigmin (0.5 mg.) and atropine (gr. $1/150$) was now given every 8 hours. In addition 0.1 mg. of prostigmin was given at the beginning of the second stage of labour. The blood group of the patient had previously been determined; she was found to be Group A, and Rh negative. Appropriate cross-matching with a selected sample of Group O. Rh negative blood from the blood bank demonstrated complete compatibility. By 6.30 a.m. on 29th March, i.e. just 24 hours after the onset of labour pains, the cervix was fully dilated with the membranes still bulging. These were ruptured artificially and the head was found to have reached the mid pelvis and to be lying in a position of deep transverse arrest.

Contractions, which had been of good quality during the earlier part of the night, had become a little weaker during the hour or two preceding this

examination. Following on the release of the forewaters however, their strength returned and three-quarters of an hour later, under anaesthesia, the occiput was rotated anteriorly without difficulty and a healthy female infant weighting 6 pounds 10 ounces was delivered with the use of forceps. Sedation during the course of labour had been effected by the administration of morphine sulphate gr. 1/6, hyoscine hydrobromide gr. 1/100 and atropine sulphate gr. 1/180, followed, towards the end of the first stage, by gr. 6 of sodium amytal. At no stage did the patient complain of undue fatigue. However, trouble developed during the third stage of labour in the form of a moderate but persistent postpartum haemorrhage. The placenta was therefore expressed by Crede's manoeuvre and ergometrine (0.125 mg.) was administered intravenously. Effective haemostasis was obtained in this way and the general condition of the patient was entirely satisfactory when subsequently transferred from the delivery room to a lying-in ward.

Three hours later she began to tremble persistently but not violently. This was accompanied by general emotional instability. The attack lasted for approximately half an hour and was the only occurrence of this character. The trembling was ascribed to the extra amount of prostigmin administered during the labour. Subsequently she expressed the opinion that she felt quite as well as before the confinement and throughout the remainder of her stay in hospital relapse of any kind did not occur. A blood transfusion was given on the third day of the puerperium and the previous dosage of prostigmin and ephedrine was maintained. The patient left hospital on the 15th day and was seen at the post-natal clinic a month later when she reported having had a short relapse some two weeks previously.

The baby was being fully breast fed but the mother noticed that she became very tired and felt "as though she wanted to go to sleep on her feet," if, through pre-occupation, she missed the proper time for taking the tablets. Seen again a month later, on the eve of her return to the country, entirely favourable progress was reported. In reply to a letter sent after a further interval of two months it was learned that no major relapse of any kind had occurred.

DISCUSSION.

The rôle of acetylcholine as a chemical transmitter of parasympathetic impulses is now clearly established, as also is the presence of a blood esterase for its destruction. It is presumed that in myasthenia gravis there is either an insufficient amount of acetylcholine or an increase in cholin esterase. Actual determination of the esterase content of the blood in myasthenia gravis has given conflicting results⁶ and, not infrequently, is found to be within normal limits. Kennedy and Wolf⁷ are not prepared to accept this conception of the aetiology of the disease and believe that the lactic acid content of muscle in myasthenia gravis is diminished as a result of some metabolic disturbance. This had the effect of neutralizing the transfer of neural impulses, dependent on acetylcholine which, in turn, is ineffective in too low an acid, a neutral or an alkaline medium. Although the ultimate biochemical changes occurring in myasthenia gravis are as yet undetermined, an improvement in the clinical condition of the patient coinciding with a prostigmin-induced fall in blood esterase level is a constant finding.

As a consequence of the considerable period of time spent in hospital, it was possible closely to observe the clinical course of the condition presented by this case during the last 4½ months of her pregnancy. In addition she was able to give a good account of the subjective manifestations noted during the earlier stages of her illness; *viz.* from June 1944 until November 1945. In this regard it would seem apparent that the condition had progressed to one of considerable severity prior to the institution of treatment with prostigmin and ephedrine and her subsequent favourable progress, in the presence of a co-existent pregnancy, is perhaps more significant for this reason.

The aggravation of symptoms prior to and during menstruation was particularly

noticeable in this case and the consistency with which this observation is made would further tend to disprove any suggestion that pregnancy may be a factor in precipitating the onset of the disease. This tendency for the patient to suffer a relapse at the time of menstruation has been put forward as evidence in favour of an endocrine disorder having an aetiological rôle in myasthenia gravis. Milhorat⁸ however, whilst commenting on this phenomenon, and whilst finding that the effective dose of prostigmin often has to be increased during menstruation, considers that the aggravation of symptoms has no aetiological significance. He believes that the association is of the same order as that observed in certain other clinical conditions, especially those in which muscular disability exists, the symptoms of which are usually increased during menstruation.

In studying the effect of pregnancy on the course of myasthenia gravis from the clinical record of this case it is to be noted that the first rational and effective plan of treatment made available to her coincided with the last 5½ months of the gestational period. Although a definite aggravation of symptoms developed during the first 3 months there was more than a suggestion of a spontaneous remission at the beginning of the second trimester and before the commencement of appropriate treatment. It was at this stage that a long and trying railway journey was successfully undertaken.

During the remainder of the pregnancy the clinical picture was one of steady improvement, punctuated by short-lived relapses at the times of the suppressed menstrual periods. The possibility of a "functional element" in these periodic relapses was considered (in view of the patient's previous experience in this regard) but objective as well as subjective phenomena were present in the form of a return

of slight ptosis and loss of distinctness in speech at these times. The only other relapse throughout the pregnancy appeared to have been precipitated by an upper respiratory tract infection.

The onset of definite labour pains was gradual and permitted an increased dosage of prostigmin and atropine to be administered by 8-hourly injections. The total duration of labour (24¾ hours) was in no way excessive in view of the primiparity of the patient, the gradual development of first stage contractions and the posterior position of the occiput. The reduction in the strength of uterine contractions towards the end of the first stage and in the early part of the second stage as well as the tendency to postpartum haemorrhage obviously point to the development of some degree of uterine exhaustion. But it is equally clear that this development was in no way a consequence of the myasthenia gravis. Deliberate rupture of the bag of forewaters at a slightly earlier stage might have been practised with advantage.

The presence of a complicated labour in a patient suffering from myasthenia gravis gives added significance to considerations governing the mode of delivery of these cases. For if, as would appear, Caesarean section is to go the way of therapeutic abortion in the management of these patients and the prostigmin-controlled cases considered essentially suitable for natural delivery, purely obstetrical complications are bound to develop from time to time. Should these manifest themselves before the onset of labour (cephalo-pelvic disproportion for example), their presence would rightly favour a decision to retain Caesarean section as the method of choice for delivery. But should such complications develop during the course of labour there is reason to believe that the management of the prostigmin-controlled case would give no undue cause for anxiety.

SUMMARY AND CONCLUSIONS.

1. The present position in regard to the management of pregnancy and labour when complicated by myasthenia gravis is briefly discussed.

2. A case record is presented describing the clinical course of pregnancy, labour and the puerperium in a patient the subject of a previously untreated and severe form of myasthenia gravis.

3. Except for an aggravation of symptoms at the onset and transient mild relapses of a periodic nature, the pregnancy was uneventful and at no stage was the need for termination of the pregnancy even contemplated.

4. In spite of the labour being complicated by a posterior position of the occiput, there were, during this stage, no untoward developments which might have been attributed to the myasthenia gravis. Nor was there any evidence of undue fatigue of the voluntary musculature.

5. Although no serious relapse occurred during the puerperium, reduction in the daily dose of prostigmin and ephedrine

could not be effected without a return of symptoms.

Acknowledgments are due to Dr. Clive Sippe, senior part-time physician to the Brisbane General Hospital, at whose request I undertook the care of this patient.

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ROYAL COLLEGE OF OBSTETRICIANS AND GYNAECOLOGISTS

A special meeting of the Council was held on Friday, September 27th, and an ordinary meeting was held on Saturday, September 28th, 1946, at the College House, with the President, Mr. Eardley Holland, in the Chair.

The Honorary Fellowship of the College was conferred on Mr. Victor Bonney in recognition of his work as a gynaecologist.

The following were formally admitted to the Membership by the President:

Hugh Rose Arthur
Samuel James Barr
Bryce Evans Blair
Catherine Isobel Blyth
Joyce Burt
Harold Burton
Guy Beadon Walmesley Fisher (*in absentia*)
Robert Leighton Hartley
Derek Jefferiss
Iola Lloyd Trevor Jones
Leslie Wallace Lauste
Margaret Orford
Hedley Charles Perry
Dwijendra Lal Poddar
Esther Mary Pollock
James Edmund Scott-Carmichael
Eric Wilfred Lowther Thompson
Thomas George Edward White

At the termination of the meeting of the Council held on Saturday, 28th September, Mr. William Gilliatt, London, assumed the Office of President, Sir William Fletcher Shaw, Manchester, and Mr. James M. Wyatt, London, assumed the Offices of Vice-President, and Mr. Arthur A. Gemmell, Liverpool, assumed the Office of Honorary Treasurer.

INDEX TO CURRENT LITERATURE

In this Index an endeavour will be made, so far as conditions permit, to maintain an up-to-date record of all titles bearing on obstetrics and gynaecology and the infant. The classification aims at making immediately available for the reader the titles under the various subject headings. In the majority of instances the title is obtained from the original publication. Where this has been impossible, the title has been obtained from the abstracting journal shown in brackets. Reprints will be welcomed and should be sent to the Editor.

Any inquiries should be addressed to Miss D. F. Atkins, British Post-graduate Medical School, Ducane Road, London, W.12.

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